TOTAL Mining Australia Pty. Limited

E.L.'S 4856, 4857 AND 4858 TOLMER PROJECT, NORTHERN TERRITORY

 $\frac{\text{REPORT ON AREAS RELINQUISHED}}{1989}$

VOLUME I - TEXT AND PLATES 1 - 9

R/88-21-U

P. MELVILLE MARCH 1989

TOTAL Mining Australia Pty. Limited

TABLE OF CONTENTS

				Page
I.	INT	INTRODUCTION		
II.	GEOLOGY			2
	2.1	REGIONAL	SETTING AND STRATIGRAPHY	2
	2.2	REGIONAL	STRUCTURE	3
	2.3	GEOLOGY C	OF THE TENEMENTS	3
		2.3.1 2.3.2 2.3.3	E.L. 4856 E.L. 4857 E.L. 4858	3 5 7
III.	EXPL	ORATION AC	TIVITIES	9
	3.1	INTRODUCT	TON	9
	3.2	TARGETS A	ND MODELS	9
	3.3	METHODS OF INVESTIGATION AND EQUIPMENT		10
	3.4	E.L. 4856	- INVESTIGATIONS AND RESULTS	12
		3.4.1 3.4.2 3.4.3 3.4.4	Ground Radiometric Traversing Geophysics Geochemistry and Thermoluminescence Conclusion	12 13 20 20
	3.5	E.L. 4857	- INVESTIGATIONS AND RESULTS	21
		3.5.1 3.5.2 3.5.3	Ground Radiometric Traversing Geophysics Conclusions	21 21 24
	3.6	E.L. 4858	- INVESTIGATIONS AND RESULTS	24
		3.6.1 3.6.2	Airborne Geophysics Conclusions	24 24

TOTAL Mining Australia Pty. Limited

LIST OF PLATES

		<u>Scale</u>	Drg. No.
Plate 1	Synthesis Map Showing Relinquished Areas	1:100000	547-046
Plate 2	SH1 - MaxMin Profiles	1:5000	547-212
Plate 3	E.L. 4856 - Location of Airborne Radiometric Anomalies	1:100000	547-210
Plate 4	Reynolds River - Magnetic Vertical Gradient Plan	1:50000	547-050
Plate 5	Gravity Helicopter Survey: Residual Anomaly Contours (North)	1:100000	547-019
Plate 6	Gravity Helicopter Survey: Bouguer Anomaly Contours (North)	1:100000	547-018
Plate 7	Gravity Helicopter Survey: Regional Anomaly Contours (North)	1:100000	547-021
Plate 8	Bouguer Anomaly Interpretation (North Sheet)	1:100000	547-063
Plate 9	Gravimetric Interpretation from Residual Gravity Anomaly Profiles	1:100000	547–062
Plate 10	Bouguer Anomaly Interpretation (South Sheet)	1:100000	547-064
Plate 11	Total Magnetic Intensity Contours	1:100000	547-057
Plate 12	Daly River - Magnetic Vertical Gradient Plan (Sheet 1)	1:100000	547–032
Plate 13	Daly River - Magnetic Vertical Gradient Plan (Sheet 2)	1:100000	547-033
Plate 14	Wingate Mountains - Magnetic Vertical Gradient Plan (Sheet 1)	1:100000	547-048
Plate 15	Wingate Mountains - Magnetic Vertical Gradient Plan (Sheet 2)	1:100000	547-030
Plate 16	INPUT Conductor Map - Sheet 1	1:25000	547-094
Plate 17	INPUT Conductor Map - Sheet 3	1:25000	547-096
Plate 18	INPUT Conductor Map - Sheet 4	1:25000	547–097
Plate 19	INPUT Conductor Map - Sheet 10	1:25000	547–103

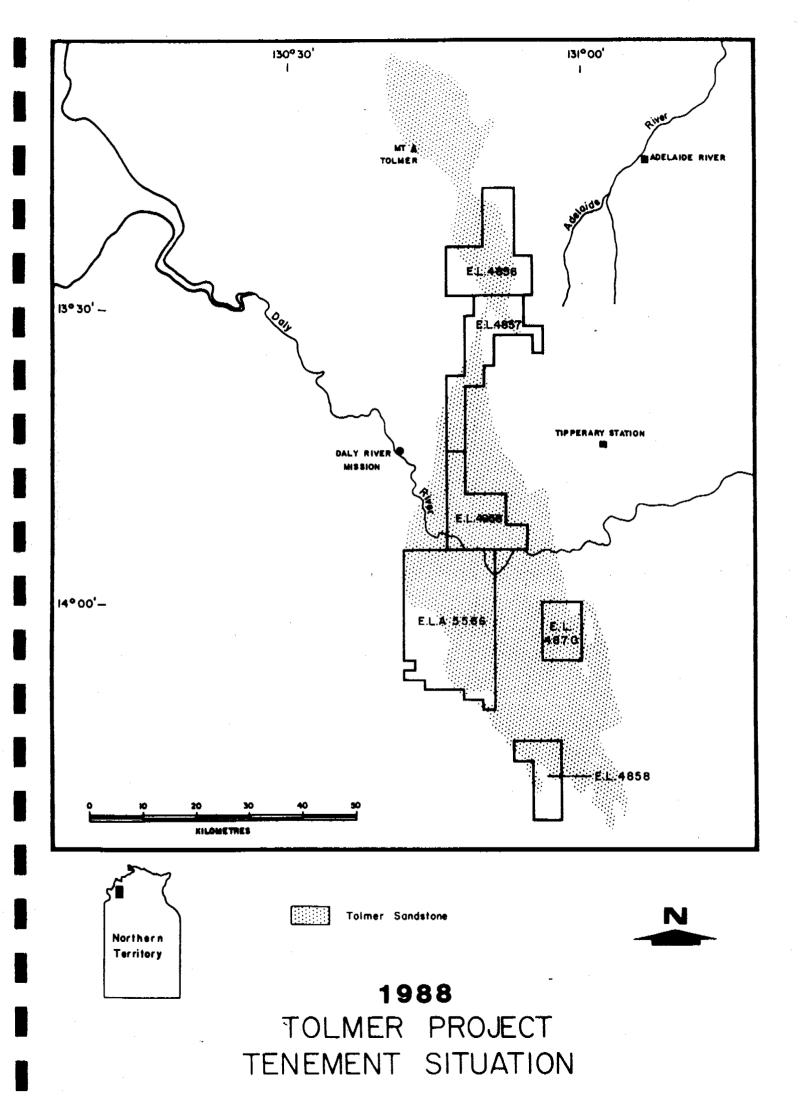
I. INTRODUCTION

The three Exploration Licences, the subject of this report, were applied for in August 1985 and were subsequently granted in March 1986.

The tenements are located in the Reynolds River, Daly River and Fish River area of the Northern Territory, being more or less centred on the Daly River settlement 150 km south of Darwin. They are contained within a block bounded by latitudes 13° 15' and 14° 20'S and longitudes 130° 40' and 141° and are aligned in a north-south direction to cover the general strike and contacts of the Lower and Middle Proterozoic rocks. All the land covered by the licences is under a Pastoral Lease held by Tipperary Station.

The northern tenements are accessible from the main Daly River-Adelaide River road and then by established tourist and station tracks. The southern tenement is less accessible by ground, with flooding of the main waterways prohibiting traffic for 5-7 months of the year. However it is served by station roads.

Exploration activities of the subject area include ground scintillometer traversing, various airborne surveys (EM INPUT and gravity), interpretation and modelling of previously acquired data and ground EM follow-up of selected conductive zones.



II. GEOLOGY

2.1 REGIONAL SETTING AND STRATIGRAPHY

The Joint Venture Licences are located on the western edge of the Pine Creek Geosyncline. The main rock types are sediments ranging in age from Lower Proterozoic to Adelaidean; Carpentarian granites intrude these sediments. The Litchfield Complex of ?Archaean to Lower Proterozoic age occurs to the northwest. The Cambrian Daly River Group obscures much of the Lower Proterozoic-Adelaidean rocks both west and east of the tenement area. The geology is illustrated on the Synthesis Map (Plate 1).

The stratigraphy is as follows (from N.T.G.S., 1983):

ARCHARAN-EARLY PROTEROZOIC: Litchfield Complex comprising high grade metamorphics which appear to include sediments, basic to intermediate rocks and anatectic granites. These are located to the northwest of the project area.

EARLY PROTEROZOIC: Burrell Creek Formation comprising variably metamorphosed sandstones and siltstones. Includes pebble and conglomeratic facies, graphitic shales/schists and some carbonate rocks (Pfb).

LATE PROTEROZOIC:

- (i) Carpentarian syn-orogenic to post-orogenic granites. Represented by the Mt. Litchfield, Allia Creek and Jammine granites and the Soldiers Creek granite at Collia (Pxgl, Pxga, Pxgi and Pgs).
- (ii) ?Early Adelaidean Tolmer Group. Comprises four formations:
 - + Depot Creek Sandstone: thickly bedded medium to coarse quartz arenite (450 m) (Ptd).
 - + Stray Creek Sandstone: flaggy micaceous, ripple marked quartz arenite (300 m) (Pts).
 - + Hinde Dolomite: dolomite, dolomitic shales and arenites, quartz arenites (+ 314 m) (Pth).
 - + Waterbag Creek Formation: red mudstone with thin arenite layers (non-outcropping) (+ 134 m) (Ptw).
- (iii) Late Adelaidean Uniya tillite (0 30 m) (Put).

PALAEOZOIC: Cambrian Daly River Group. Basal conglomerates, Antrim Plateau Volcanics (basalts) and the Tindall Limestone (£1a).

2.2 REGIONAL STRUCTURE

The principal structural feature of the region is the Giants Reef Fault which has caused obvious displacement to the various rock units it traverses. The zone extends some 30 km northeast of Rum Jungle where it loses its identity under alluvial cover; southwards it extends well outside the Company's area of interest. The Giants Reef Fault is considered to be the northern extension of the Hall's Creek Mobile Zone. Parallel structures, the largest being the Stapleton and Rock Candy Range Faults and many minor ones traverse both the Burrell Creek Formation and Tolmer Group rocks.

Folding is present both on a small and large scale. The Burrell Creek sediments are tightly folded with fold axes striking generally N-S. The overlying Tolmer Group dips gently eastwards forming the extensive Daly River Basin. Folding occurs in the Tolmer adjacent to the Rock Candy Fault forming an elongated domal structure thought to be underlain by Carpentarian granite. The Cambrian sediments are nearly flat lying.

Regional dips are moderate to steep westerly for the Burrell Creek Formation and gently eastwards for the Tolmer Group. Strikes are N-S to NW-SE.

2.3 GEOLOGY OF THE TENEMENTS

2.3.1 E.L. 4856

+ Burrell Creek Formation

Lower Proterozoic sediments are confined to the lower western and eastern sides of the E.L. Here they form steep sided hills abutting the Tolmer Sandstone or are present as flat soil—covered plains. Lithologically, the facies comprise fine to coarse sandstones interbedded with micaceous meta-siltstones. The former are quartzitic with, in places, a well developed lineation of the rounded quartz grains; thin conglomeratic and pebble bands occur. The silty variants are often rich in sericite and may vary in colour from pale brown to reddish; regional metamorphism has produced a phyllitic rock. The presence of higher grade and alusite schists in places could be indicative of tectonic and/or intrusive activity.

Much of the non-outcropping country covered by black soil areas and swamps is thought to be underlain by easily erodable schists and meta-siltstones.

A thin, sand-covered area near Surprise Creek, wedged between the Giants Reef Fault and outcropping Lower Proterozoic quartzites/schists has been drilled extensively in the past. Drill logs indicate the presence of chloritic mica schists, carbonaceous shales and thin dolomite bands. An informal name, the Surprise Creek Member, was applied to these rocks although

4.

they undoubtedly are part of the Burrell Creek Formation which has undergone localized intense deformation associated with activity along the Giants Reef Fault zone.

+ Tolmer Group

The basal Depot Creek Sandstone Member covers much of the licence area; it forms both an eastern and western contact with the Burrell Creek rocks, in part unconformable, in part faulted. Regionally, the Tabletop Range is a broad, shallow depression with observed west and east dipping strata on the respective sides, where not affected by faulting. Remnants of younger Stray Creek Sandstone were located during surface prospecting in the more northerly parts of the tenement, these not having been mapped previously. These outcrops are either erosional remnants or have been preserved in localized fault bounded zones.

The Depot Creek is typically a massive, blocky, generally fine to medium grained quartzite often reddish in colour. Bedding is obvious and, in places, is well defined by pebble bands. The Stray Creek Member comprises laminated sandstones with interbedded reddish shaley mudstones. In the field the two members can be distinguished by radiometry. Current bedding, ripple marks, slumping, autobrecciation and sand dikes are all represented in the basal Depot Creek, appearing to be a consistent feature regionally. Ripple marks were also observed in the Stray Creek Sandstone.

+ Uniya Tillite

At AMG grid reference 043169 (Reynolds River 1:100,000 sheet) a previously unmapped outcrop of glacially derived sediment was located during traversing. Lithologically it is a dark coloured fine grained sandstone containing "dropstones" up to 0.5 m diameter of Depot Creek Sandstone. Only a thin layer has been preserved but the coverage is fairly extensive, being several hundred metres in area. Elsewhere, unconsolidated boulder deposits are considered to be of glacial origin.

+ Mesozoic

Lateritized sediments thought to be of Mesozoic age form flat-topped hills overlying Depot Creek Sandstone. Most of these features are located along or adjacent to the mid-Proterozoic unconformity. Other areas of laterite which can be identified on aerial photographs are considered to be derived directly from the Tolmer Sandstone.

+ Granite

Two granite intrusives are present, located approximately 10 km apart. The most northerly is the Reynolds River Granite, the other has no formal name but has been termed the Alligator Creek Granite. Both are represented by very poor outcrop, the granite being obviously subject to rather quick weathering and

decomposition; occasional exposures are seen in rapidly eroding creek beds. Generally the extent of the bodies has been judged by both photo signature and eluvial deposits on the ground surface. F. Lillie's (TOTAL, Paris) satellite interpretation does confirm greater known extent of the Reynolds River Granite and more or less agrees with the current interpretation. Similarly, the granitic body which underlies the Fault Wedge Zone was located accurately by Gravity methods. Drilling has proven it to be of greater extent westwards obscured under 200 m+ of Tolmer Sandstone.

Outcrop observations on the Reynolds River Granite show two variants: pink and grey. The former has been described as a "porphyritic adamellite" and occurs as isolated, rounded, boulder-like outcrops; the latter is far more widespread and poorly outcropping. It is generally a hornblende-biotite granite. Observed outcrops in the Fault Wedge indicate a similar granite type to the hornblende-biotite variety; a description gained from drill core indicates a medium grained monzonitic granite showing a distinctive chloritic-hematitic alteration near the contact.

Contact metamorphic effects are not observed around the Reynolds River Granite, however, as previously described, there is an alteration aureole adjacent to the other.

2.3.2 E.L. 4857

+ Burrell Creek Formation

The lithologies represented here comprise both meta-argillites and arenaceous types, the latter being more widespread than elsewhere. The structural trend is north-south with bedding vertical to steep west. Local folding occurs mainly north and northeast of March Fly, the structures being south plunging. Many photo lineations cross-cut the bedding at right angles; displacements are small scale.

Progressing south along the unconformity there is a gradual change in the facies exposed due to the combination of regional bedding strike and the trend of the contact. Lithologies. exposed to the north, gradually "disappear" under the Tolmer Group producing a continual succession of younger rocks along the traverse zone. This is illustrated by mapping (Robertson Research and Mobil) and ground traversing (T.M.A.) where coarse sandstones and conglomerates predominate adjacent to the unconformity east and north of March Fly. These coarser lithologies have been previously mapped as Noltenius Formation (BMR) and were considered older than the Burrell Creek This stratigraphic name has since been abandoned with all Lower Proterozoic rocks now being grouped within the Burrell Creek. The stratigraphy is generally as follows: coarse sandstones and grits with thin conglomeratic horizons (basal) becoming finer grained with a predominance of meta-siltstones of

variable composition giving rise to sericite and quartz-muscovite schists. Interbedded with these are further sandstones of variable grain size and some thin conglomerate beds. Locally, carbonaceous (sometimes, but rarely, graphitic) shales occur as thin bands as do isolated outcrops of black silicified greywacke. All these facies occur at the March Fly prospect.

+ Tolmer Group

The Depot Creek Sandstone forms a prominent escarpment in places trending NNE-SSW. Outcrop of this basal unit is restricted to an average width of approximately 1.5 km due to overlying tillite and Cambrian limestone northwards (Blackfellow Creek area) and Stray Creek Sandstone elsewhere; the latter has an unconformable relationship with the Depot Creek. East and north of Hayward Creek the unconformity surface is well preserved with little erosion of the Burrell Creek. Topographically the landform is fairly flat lying across the contract and this extends perhaps 500-800 m west to where the escarpment is developed in Burrell Creek sediments.

Regional dips taken by the NTGS and field observations show the basal sandstone member to be tilting very gently eastwards with measurements ranging from $10^{\rm o}-20^{\rm o}$ along most of the contact.

The series of parallel E-W faults in the Burrell Creek Formation also affect the Tolmer although this is not acknowledged on the NTGS maps. Minor offsets in the contact were observed during the traversing; sheeting structures in the sandstone indicated the fault trend.

Lithologically the Depot Creek Sandstone is a fine grained quartz-arenite with thin pebbly bands throughout; local conglomerate lenses were seen in places. Sedimentary features such as ripple marks and current bedding are common.

+ Uniya Tillite

Glacial features and sedimentation occur in a N-S trending zone from Hayward Creek north to the Reynolds River. The feature is thought to represent a glacial valley coinciding with a structural depression within the Tolmer Sandstone; this depression has been identified by geophysics and drilling at two INPUT anomaly locations.

Glacial sediments are present as both unconsolidated till (e.g. Hayward Creek area) and as a fluvio-glacial shale/ sandstone sequence in both outcrop and drill cuttings (INPUT anomalies 2851 and T11). The shales are red and varve-like while the sandstones are poorly sorted facies containing variously sized pebbles and large dropstones of Depot Creek Sandstone.

The most outstanding glacial feature is the striated pavement at Hayward Creek. Other pavements were found by T.M.A. geologists to the north at the Reynolds River and also near Alligator Creek (T11).

7.

+ Daly River Group

The Cambrian Antrim Plateau Volcanics and Tindall Limestone unconformably overlie both the Tolmer Group and the glacial sequence. Drill holes at both T11 and 2851 INPUT anomalies intersected a thin layer of amygdaloidal basalt covering the glacial sediments; a palaeosol was identified in some holes. Muddy shale beds and some pebbly horizons might also be of Cambrian age though this is not definite.

2.3.3 E.L. 4858

+ Burrell Creek Formation

Only selvedges of the Lower Proterozoic remain, either as strongly altered rafts within the younger Soldiers Creek Granite or as thin strips preserved along the contact with the Tolmer Group. Several observations were made during the various helicopter surveys (1986, 1988); some of the 'rafts' were prospected to ascertain radiometric backgrounds; the composition of these bodies comprises highly altered and veined schists and quartzitic rocks; many aplitic/pegmatitic variants of the granite intrude them. Black tourmaline is common in the intrusives; and alusite occurs in the altered sediments.

Adjacent to the Tolmer Group outcroppings a thin wedge of Burrell Creek is preserved between it and the Soldiers Creek Granite. These outcrops have been looked at in the field in the southern part of the E.L. several kilometres north of the Collier Waterhole. Along the granite margins good exposures of the intrusive contact can be seen with granitization and partial ingestion of the Burrell Creek; this zone is only a few metres wide passing into unaltered meta-sandstones and schists.

+ Tolmer Group

The mid-Proterozoic sandstones outcrop regionally as NW trending, NE dipping strata. The best exposures are present in the Fish River Gorge to the north where both the Depot Creek and Stray Creek members can be seen. The upper member, the Hinde Dolomite, is present in the NE corner of the licence comprising dolomites, dolomitic sandstones and shales. Structurally, the Group is undisturbed with fairly constant strikes and dips. Some regional photo lineaments trend parallel with the strike and are responsible for some displacement. Minor faults have been observed in some of the work areas (SV10) showing localized cross-strike displacement.

+ Uniya Tillite

Some terraces of unconsolidated pebble/boulder deposits were seen during contact traverses. One example occurs on a flat section of ground between outcrops of Burrell Creek and Tolmer.

The pebbles up to 12 cm diameter occur as a thick veneer on soil; they are very rounded and smooth and resemble similar deposits in the norther E.L.s which have been mapped as till.

+ Mesozoic

Sections of what are considered to be Mesozoic sediments outcrop on the two INPUT anomaly areas explored during the season. The basal unit is a ferruginous sandstone often containing large to boulder-size rounded clasts of Depot Creek. Similar facies seen in E.L.s 4856 and 4857 are mapped as part of the Uniya Tillite, therefore its status here must remain in question.

Overlying the 'boulder sandstone' are several metres of laminated, silicified siltstone with some thin layers of meta-sandstone. This, in turn, is covered by a thin laterite layer.

+ Granites

A small portion of the rather extensive Soldiers Creek Granite is present within the E.L. forming an intrusive contact with the Lower Proterozoic, discussed above, and unconformable with the overlying Depot Creek Sandstone. The granite is described as a post-orogenic granitoid comprising a coarse grained muscovite-biotite adamellite and granodiorite. Certain phases of the granite have produced disseminated cassiterite mineralization which has been concentrated later by weathering processes. The gold deposits at Fletchers Gully which occur in carbonaceous facies of the Burrell Creek Formation could be related to the granite intrusion.

Field observations of the granite were discussed earlier under the Burrell Creek heading.

III. EXPLORATION ACTIVITIES

3.1 INTRODUCTION

The principal aim of the 1988 programme was to carry out detailed exploration over conductive zones as defined by the aerial INPUT survey and to follow-up where necessary with drilling. Other activities were confined to further evaluation of the Eccles II and Surprise Creek North prospects, and some ground investigation of subtle airborne radiometric anomalies occurring within the Tolmer Sandstone.

3.2 TARGETS AND MODELS

The Tolmer Project was chosen as an exploration target by T.M.A. because of the many geological similarities, both regionally and locally and lithologically and structurally, as the Alligator River Uranium Province some 250 km to the east.

The sequence of Lower Proterozoic sedimentation appears to have been fairly uniform across the Pine Creek Geosyncline with subsequent folding and syn-post orogenic granitic intrusive episodes. These have given rise to a series of regional synclinoriums.

Middle Proterozoic sedimentation most likely covered the entire Geosyncline; this episode comprised the Katherine River and Tolmer Groups of sandstones and associated rock types. The B.M.R. have placed the former as the oldest with an unconformity separating the two groups. The Depot Creek and Kombolgie Sandstones are considered by T.M.A. to be stratigraphical equivalents supported by near identical lithological, physiographical and botanical features. The only differences are in the facies variations reflecting the depositional environment, i.e. basic volcanism in the Kombolgie and carbonate deposition near the end of the Tolmer sedimentation.

The Burrell Creek Formation, which immediately underlies the basal Tolmer unit, the Depot Creek Sandstone, is the youngest phase of early Proterozoic sedimentation in the Pine Creek Geosyncline. Further to the northeast, at Rum Jungle, the Burrell Creek Formation is unconformably underlain by the entire sedimentary sequence which has been exposed around the margins of the Rum Jungle and Waterhouse Complexes; the sequence comprises, from oldest to youngest, the Namoona, Mt. Partridge and South Alligator Groups. The Cahill Formation, host to uranium deposits in the ARUF is stratigraphically equivalent to the Namoona Group; various sedimentary facies have been observed in the Reynolds River by T.M.A. and others which may be Namoona equivalents. These occurrences include the tracts of swampy black soil and alluvium covered country north and south of Surprise Creek where bedrock drilling has confirmed the presence of various schists: chloritic and graphitic and lenses of dolomitic sediments. Near Prousts Crossing west of Surprise Creek, probably Namoona equivalents including carbonaceous shales, graphitic schists and Folding in the region has most likely exposed dolomite outcrop. With the intensity of prospection covering these older sediments. the Burrell Creek sediments it cannot be discounted that favourable lithologies could be found in these younger sediments.

10.

Following from the above, two principal exploration targets have been outlined:

- (i) the unconformity model,
- (ii) the granite contact model.

Applying these to the Tolmer Project, the main points are:

(i) Unconformity Model:

- the Burrell Creek/Tolmer unconformable contact is relatively flat lying,
- the underlying sediment, i.e. BCF and ?Namoona, have suitable facies present: carbonaceous, graphitic, dolomitic.
- suitable degree of metamorphism: greenschist and minor amphibolite facies,
- possible reactivated Archaean doming during the Middle Proterozoic,
- presence of uranium in the region: the Rum Jungle field and various small occurrences in Burrell Creek sediments.
- abundant groundwater movement,
- intrusion of Proterozoic granites giving an adequate heat source to activate and maintain convection cells which may act to concentrate uranium at physically or chemically suitable sites.

(ii) Granite Contact Model:

- intrusion of upper level granites or granitoids,
- a suitable host rock: carbonaceous shale, graphitic schist, dolomite.

Exposed granites are in evidence south of the Daly River and these intrude the Burrell Creek Formation.

3.3 METHODS OF INVESTIGATION AND EQUIPMENT

Systematic work over the defined EM conductors involved initial location with the aid of aerial photography and 1:100,000 topographic maps. Those inaccessible by 4-WD vehicle were reached by helicopter, a Bell Jetranger from Rotor Services, Darwin. Once the conductive zone had been identified the area was gridded, usually with 100 m spaced cross lines and 25 m intervals marked along these lines. The general sequence of activities on each grid is as follows, however not all were employed in each case:

- + initial MaxMin Geoterrex, Sydney,
- + VLF TOTAL staff,
- + alphaCard TOTAL staff.
- radiometrics TOTAL staff.
- geological mapping TOTAL staff,
- selection of drilling targets TOTAL staff.
- + site preparation by bulldozer North Australian Haulage, Darwin,
- + drilling: percussion and/or diamond Rockdrill, Brisbane,
- + downhole logging Century Geophysics, Adelaide or TOTAL staff,
- laboratory analyses of cuttings and core Amdel, Darwin,
- thermoluminescence studies on Tolmer Sandstone Mark Hochman,
 Adelaide University.

During the campaign the MaxMin ground electromagnetic surveying was carried out by a crew from Geoterrex using a 150 m separation between receiver and transmitter along profiles either 100 m or 200 m apart. Equipment used was an Apex Parametrics MaxMin II frequency domain electromagnetic system.

The MaxMin survey was performed only on the INPUT anomalies located on or immediately adjacent to the Depot Creek Member of the Tolmer Sandstone as it was ascertained that the method was unable to define a target below a thickness of overlying facies greater than that of the Depot Creek. The latter, with a maximum thickness in excess of 400 m, is already the absolute maximum through which the MaxMin can "see" even when considering the most favourable hypothesis.

The purpose of the ground EM MaxMin survey was to determine the presence and location of conductive belts, possibly corresponding to facies of graphite-chlorite schists within the Burrell Creek Formation below the overlying Depot Creek Sandstone. Our detailed survey of the Burrell Creek formation outcropping near the Depot Creek unconformity has confirmed the presence of such favourable facies, most often accompanied by uranium mineralisation or anomalous radioactivity (e.g. Eccles I and II).

The radon survey was specifically applied to the conductors defined by the MaxMin readings. Radiometric surveying and geological mapping was applied to the total surface of each grid.

The MaxMin survey has provided two types of anomaly:

- some responses corresponding to wide, shallow "bad quality" conductors,
- some responses which could correspond to more deeply seated conductors.

The interpretation of the MaxMin anomalies has been done considering also the limit of mapped geological facies and/or the structural features recorded during the systematic survey of the gridded area.

VLF was run over as many lines as possible on each grid; its purpose was to define the presence of shallow conductive zones such as overburden, to help in the interpretation of the MaxMin responses, and to outline structures which affect both the Tolmer Sandstone and underlying Burrell Creek Formation. The equipment used is a Geonics EM16 unit, manually operated.

The survey was run on the Japan (NDT) and North West Cape (NWC) transmitters to obtain information on both N-S and E-W sets of faults. Unfortunately, the North West Cape Station emitted very irregularly which did not enable us to obtain values on every reading location of the grid and so get systematic information on the E-W oriented faults. Attempts will be made during the 1989 campaign to complement the readings from the North West Cape emitter and to work on a closer grid when detailed readings appear necessary.

Radiometric and radon-detecting procedures were implemented concurrently, generally over selected grid lines; the surveys were limited to areas where both favourable conductive trends and suitable lithologies occurred, the latter being Tolmer Sandstone cover. Lines were rarely extended into outcropping Burrell Creek Formation.

Equipment utilized is the portable SPP-2 scintillometer and an alphaNuclear Alphacard device. A Toyota 4-WD with mounted Gemco auger drill prepared a 40 cm deep, 15 cm diameter hole in which is placed an inverted plastic flower pot with attached Alphacard. The hole was sealed with large, thick, plastic bags held in place by soil/rubble. The cards were allowed to "sit" for a minimum of 12 hours and then read using a programmed counter which gives a value in counts per minute. Scintillometer readings were taken both "downhole" and on surface.

Where access was not available for the auger rig, all holes had to be excavated by hand.

3.4 E.L. 4856 - INVESTIGATIONS AND RESULTS

3.4.1 Ground Radiometric Traversing

Much of the 1986-1987 field season involved traversing the Lower-Middle Proterozoic contact; scintillometric readings were taken at 25 m intervals on 50 m spaced lines. Traverse lines were designed to cover at least 800~m-1000~m of Burrell Creek Formation and extend 100-200~m onto the Tolmer Sandstone plateau. Geological observations were made at each station.

Some of the area relinquished was not explored in any detail as preliminary studies had shown its unsuitability, according to our geological models, of having the potential for an economic uranium discovery.

3.4.2 Geophysics

Several airborne geophysical surveys have covered the licence area. A widely spaced gravity survey by the B.M.R.; detailed spectrometry and magnetics by the N.T.G.S. (1983); closely spaced, systematic heliborne gravity work by the Joint Venture (1986) and systematic EM INPUT in 1987 by Geoterrex Pty. Ltd. for the J.V.

The two gravity surveys were integrated and reinterpreted by consulting geophysicists, TERRA GEOPHYSICS, while the N.T.G.S. data was collated and presented as stacked profiles by Geospex Associates Pty. Ltd. (Sydney) for further interpretation by T.M.A. geologists. The detailed INPUT programme provided targets for ground follow-up which was commenced on a preliminary, experimental basis in November 1987. This was continued as an intensive 6 week programme during the 1988 dry season.

The Synthesis Map (Plate 1) shows regionally plotted data in respect of the U/Th anomalies, Gravity (Bouguer) and magnetic trends.

Details of the various surveys is set out below:

+ N.T.G.S. Data

The following data was presented to the J.V. by Geospex:

- 1. Flight line diagrams.
- 2. Stacked profiles of all flight lines covering the joint venture tenements and the area covered by the Tolmer Sandstone. These show the following parameters:
 - + Total (cps)
 - + U (cps)
 - + U corrected (cps)
 - + Thorium (ppm)
 - + Potassium (%)
 - + U/Th
 - + U/K x 1000
 - + Altimeter (m)
 - + Magnetic gradient (nT/m)
 - _ Total magnetic (nT)
- Stacked profiles of the Magnetic Gradient per 100,000 sheet, i.e. the Reynolds River, Daly River and Wingate Mountains sheets.
- 4. Stacked and shaded profiles of the U/Th.

Particular attention was paid to the radiometric data; many subtle U anomalies were outlined within the basal Tolmer Sandstone and these were prioritized for future ground follow-up. The points were located and plotted on colour 1:25,000 aerial photographs; the

ground work was commenced in the latter part of 1988 with assistance from a helicopter as many of the locations were inaccessible by vehicle. (See Plate 3 for locations.) The results of this work are detailed below:

+ Photo Run 9E, No. 1610 centred at AMG 995240. Two linear groupings — one of 2 anomalies and the other of 3; the latter trend continues some distance northwards (see below). Again the setting has been mapped as Depot Creek but there is also considerable outcrop of Stray Creek Sandstone. Major fracture sets are NE-SW with N-S to E-W directions of lesser significance. The anomaly trends give the appearance of paralleling N-S fractures however they could be related to any of the cross fracture sets.

Radiometric backgrounds were noted to vary between 30-50 c/s depending upon the lithology - Ptd and Pts respectively. Thin laminae of purplish coloured micaceous siltstones occur exposed in the drainage channels, these give locally high readings of 80 c/s. There is no ground indication of the anomalies apart from the higher background of the shaley facies within the Pts; in two cases the plots appear to correspond to outcrop positions. Elsewhere, fracture zones might be responsible for subtle radon emanation only detectable from the air.

+ Photo Run 9E No. 1610 centred at AMG 005250. Three anomalies, two south of Red Rock Creek, the third on the northern bank of the creek.

As mentioned above, two of the plots line up along a N-S trend which is traceable for about 4 km. The area traversed comprises both outcrop and sand-soil-rubble cover. Background is low: 20-30 c/s with no anomalies detected. There is no apparent reason for the airborne anomalies.

+ Photo Run 9E, No. 1610, centred at AMG 000260. A mostly sand and soil covered area with only sparse outcrop. A partly faulted-partly unconformable contact between the Lower and Middle Proterozoic exists approximately 0.5 km to the north; INPUT anomaly SHI is located 2.5 km to the ENE.

Three plots are located at the heads of tree-lined drainages, minor tributaries of Red Rock Creek. The area was traversed without locating any anomalous readings; various sets of fractures traverse the zone, the presence of these being the only explanation for their occurrences.

+ Photo Run 12E, No. 546, centred at AMG 005145. Comprises an area of about 2.5 km² containing 9 anomalous points; three alignments are present, all with N-S trends more or less coincident with regional photo-structures.

The easternmost line corresponds to a laterite/sand covered area in contact with outcrops of Depot Creek Sandstone - possibly fault controlled. A ground anomaly of 125 c/s was located in outcrop on the northern extension of this line (AMG 001151).

The facies present is similar to those seen further north - a mauve, fine grained siltstone. Here, however, the enclosing sandstones are considered to be Depot Creek.

The various other airborne anomalies occur within a large, flat area totally covered by sand and soil with occasional outcrops of laterite. No ground detections were made; a fairly constant radiometric background of 70 c/s was obtained. Areas of Ptd outcrop gave 40 c/s.

Photo Run 12E, No. 2546, AMG 009119. A group of three anomalies located on, or adjacent to, tributaries of Tableland Creek and possibly related to forested areas on springs or seepages. Ground investigations confirmed a high background of around 80 c/s on the southernmost point; the others were not satisfactorily explained. There could be a structural affiliation with the central anomaly — its position coinciding with the intersection of variously oriented fractures.

+ Summary

The aim of the anomaly check was to locate and assess various subtle anomalies supposedly associated with the basal Tolmer Sandstone. It appears that some of the areas have been incorrectly mapped as the Depot Creek Sandstone, the anomalies instead being within the Stray Creek Member and probably representing the higher radiometric background inherent in this lithology. Because the Pts outcrops are localized — probably exposed in minor fault blocks or as residuals — identification from aerial photos is impossible.

As derived from the field, the anomalous areas can be assessed broadly as follows:

- contrast anomalies; sudden variation in background between Pts and Ptd or Pts and recent cover,
- high spots within Pts (and Ptd?),
- radon bearing springs,
- laterite.
- radon emanations along fault/fracture zones,
- no observed cause.

In conclusion, there still remains doubt as to the origin of many of the anomalies and it is difficult to assign a definite cause for them. Where the Stray Creek Sandstone is involved, the cover thickness to any Lower Proterozoic source would be too great to have economic significance; similarly those in Depot Creek Sandstone well into the plateau zone might also have large thicknesses of sandstone to the unconformity. Nevertheless it can be considered that clusters along or within significant structurally disturbed zones represent leakages from a buried radioactive source. This is compatible with the proposed model for Tolmer.

U/Th and U anomalies are not confined to specific stratigraphic units as was initially predicted. It is obvious that there is at least some structural control exerted on the anomaly distribution, e.g. the Giants Reef Fault is anomalous in parts.

+ <u>Magnetic Modelling</u>

In order to establish the nature of the sources of some magnetic anomalies detected during the regional airborne magnetic survey over the Reynolds River, Daly River and Wingate Mountains 1:100,000 sheets carried out by the N.T. Geological Survey, three selected anomalous zones were chosen for the modelling of the magnetic data.

One anomalous zone occurs on the Reynolds River sheet while the other is on the Daly River sheet within the now relinquished E.L. 4958.

Reynolds River Sheet

The location of the airborne anomaly is shown on the synthesis plan (Plate 4). The coordinates of the centre of the magnetic anomaly are 690000E/8535000N and the position is about 3 km southeast of Mt. Tolmer.

The anomaly was detected within the area covered by the Depot Creek Sandstone, which is thickly bedded, medium to coarse grained sandstone occurring in the upper part of the Middle Proterozoic succession of the Pine Creek Geosyncline.

The anomaly is asymmetric and elongated in a NE-SW direction with negative values to the SE side. The amplitude of the anomaly is 74 nT.

Modelling of the magnetic data shows that the anomaly could be produced by a dyke-like body with a susceptibility of 0.03 S.I. units (about 1% of magnetite) and with the following configuration.

Width:

100 metres

Depth to top:

100 m (below surface)

Dip:

 $65 - 70^{\circ}$ south

Strike:

 $25 - 30^{\circ}$

The centre of the dyke is about 250 m south of the maximum magnetic values - or 4.750 km along profile line.

Comments

The preliminary conclusion from this work is that the depth to the basement below the Tolmer Sandstone is likely to be within the limits required by the economic modelling. It seems that the basement/sandstone unconformity is undulating, dependent partly on the upward movement of the intruding granite bodies.

It was found that the Cretaceous capping over the Tolmer Group units gave a strong magnetic signature which may have obscured that coming from a deeper seated source.

+ Gravity

This survey has outlined the outcropping Reynolds River Granite on the central east side of the E.L. and is indicating a second submerged body on the southern border of the licence. The latter is present within E.L. 4857.

+ Conclusions

Relating to the above magnetic/gravity survey, the following general conclusions can be drawn which are relevant to the project area as a whole:

- There are a number of granitic intrusive bodies beneath the Tolmer Sandstone probably forming ridges and troughs. Some of these are thought to have been Archaean palaeotopographic highs which, because they are along zones of structural weakness (deep seated faulting) were the locii of later granitic intrusion in late Lower Proterozoic or early Middle Proterozoic.
- (ii) The Archaean ridges existing during the sedimentation of the Lower Proterozoic sediments have acted as near-coast islands around which back reef type facies of carbonaceous and calcareous sediments have been deposited. This is clearly seen just to the north at Rum Jungle and is interpreted to exist beneath the Tolmer Sandstone to the southwest.
- (iii) The Giants Reef Fault, a very major structural element in the Pine Creek Geosyncline, has afforded extensive related faulting and structural deformation. This can be seen from the gravity, radiometry and magnetic survey results. The Giants Reef Fault appears to trifurcate west of the northern boundary of E.L. 4858. Here it runs north as the Giants Reef Fault, NE as the Stapleton Fault and ENE as the Rock Candy Range Fault. This splitting up of the main fault (feathering) occurs at or near the point where the stratigraphic trend of the Tolmer Sandstone changes from N-S to NW-SE.

- Uranium exists within both the Lower Proterozoic and Middle Proterozoic horizons. This is shown by the U/Th ratio, the number of U anomalies and the anomalies found by ground prospection. The U/Th anomalies often occur on the western flank of the gravity anomalies, i.e. the interpreted reactivated Archaean palaeohighs. This is important to the model which implies that the uranium generated from the sediments of the Archaean (Litchfield Block) has been trapped within the back reef facies and concentrated particularly along faults active post— and pre— the deposition of the Tolmer Sandstone.
- (v) Many faults have been defined by the U/Th and also the total count radioactivity results.
- (vi) Dolerite dykes occur particularly in the Reynolds River sheet beneath the sandstone cover. In the south they may also exist but the magnetic signature is being masked by the Cambrian and Cretaceous sediments.

+ EM INPUT Survey

This survey was flown by Geoterrex Pty Ltd. in July, 1987 and covered all tenements of the Tolmer Project. The survey was designed to cover the Tolmer Group sediments in order to located conductive features within the Lower Proterozoic Burrell Creek Formation, specifically graphitic/carbonaceous facies which occur below the unconformity.

Many conductor anomalies were found during the survey; it was attempted to identify the source of these conductors by utilizing the geological data at hand in combination with modelling based on the EM results.

Regionally, 69 flight lines for 968 line-kilometres were flown, followed by infill lines of 80 km. The locations of all the conductors to be investigated appear on the Synthesis Plan.

Procedure - General Comments

After each flight, the tracking camera films were developed and the analog charts were sorted and annotated. As the charts are on thermal paper, which tends to fade with time, it is recommended to take a more permanent photocopy as soon as the recordings become available. After locating the charts in relation to the navigation photo strips, anomalies were selected and marked on flight-line overlays at 1:25,000 scale.

The data quality has been excellent throughout the survey; efficient work from the ground crew allowed the revision of the complete survey and the selection of infill areas one day after the end of the last flight.

During the survey, the manager of Tipperary Station was kept informed of the whereabouts and purpose of the aircraft.

Interpretation and Results

The preliminary results are based on the field evaluation of the anomalies. The plots on the 1:25,000 maps are approximate only; more accurate are the anomaly locations on the colour photographs set.

Three models were followed during the field interpretation: two indicating horizontal surface conductors (thin sheet and half-space) and one indicating a sub-vertical conductor. Only the "vertical" anomalies were plotted on colour photographs.

The symbols used on the photo set to indicate the anomalies are:

```
Response in channels 11 or 12: type A Response is channels 0 or 10: type B Response in channels 7 or 8: type C Response in channels 1 to 6: type D Minor anomalies.
```

On the overlays the ratio between channel 2 and channel 10 amplitudes and the altitude from the ground were also given.

Spatially close anomalies were grouped in "areas", generally reflecting a particular geological environment. A total of 61 areas was thus defined. Unfortunately, none of them indicates the expected occurrences of graphitic schist beneath the sandstone cover. A test flight was carried out over a known graphitic conductor in the Rum Jungle area, in order to compare the amplitude and persistency of the anomalies.

The areas fall broadly into four categories:

- . Conductors in exposed Burrell Creek Formation ("basement").
- Conductors along faults.
- Conductors in Tolmer Group.
- . Conductors in Cambrian Volcanics and/or the Cretaceous.

The anomalies that occur in Cretaceous are generally located near the edge of a cliff; they could indicate the presence of a thin layer of Antrim Plateau Volcanics in the pediment between Cretaceous and Proterozoic Sandstones or be a laterite response.

Some anomalies appear to line up or coincide with rivers and billabongs.

The anomalies located by the survey which fall within the relinquished blocks are listed below:

- selected INPUT conductor:

```
Sheet 1: T1
Sheet 2: SV1, SH1
```

Only SHI was followed up with ground EM; a description of this anomaly and work performed is given below:

SH1

Located at AMG 020270 Reynolds River Sheet, photos Run 9E, 1610-1611. The anomaly is situated on Depot Creek Sandstone approximately 750 m south of the Burrell Creek/Tolmer contact. The contact is faulted in an east-west direction and was extensively covered by radiometric traversing during the 1987 field season; no radiometric anomalies were discovered.

The Depot Creek Member outcrops extensively in the anomaly zone occurring as a massive blocky quartzite. It is traversed by numerous NE-trending fractures.

A grid was pegged to cover the anomaly, the base line being 0.5 km north-south with 1.4 km cross lines every 100 m. A MaxMin II survey was the only activity carried out; results of the survey showed the environment to be strongly resistive with no conductors. The source of the INPUT response is not yet explained. (Profiles are shown on Plate 3.)

3.4.3 Geochemistry and Thermoluminescence

Parts of the relinquished area, specifically that which covered the Lower-Middle Proterozoic contact has been sampled for element analyses as well as for thermoluminescence study. All of these samples were of Tolmer Sandstone, collected adjacent to the unconformity where both geochemical and TL effects would be manifested. The analyses covered U and Mg, the latter of which indicates magnesium metasomatism, an important alteration feature of the ARUF deposits.

The effects of radiation are illustrated by the TL study which indicates if uraniferous fluids have circulated through the sandstone adjacent to the unconformity or if there are nearby concentrations of uranium mineralization within the favoured depositional zones.

Location of anomalous TL samples is plotted on the Synthesis ${\sf Map}$.

3.4.4 Conclusion

As a result of a thorough ground and airborne exploration programme implemented by the J.V. it is concluded that the relinquished part of E.L. 4856 does not have potential for economic uranium deposits.

3.5 E.L. 4857 INVESTIGATIONS AND RESULTS

3.5.1 Ground Radiometric Traversing

Four sub-blocks in the northwest corner of the tenement would have been within the Lower-Middle Proterozoic contact traverse zone. The contact here is faulted rather than unconformable, striking NE-SW; much of the Burrell Creek lithologies are non-outcropping north of the main road, being obscured by a thick cover of sand or, in some cases, terraces of unconsolidated Tolmer boulder deposits. Sufficient exposure does occur south of the road which enabled an assessment to be made of the potential of the area.

The remaining blocks are either well within the Tolmer Group or in completely non-prospective terrain, i.e. Cambrian sediments.

Approximately 8 km of contact were covered representing 160 traverses.

3.5.2 Geophysics

As with E.L. 4856 the regional airborne surveys covered this licence area in full. For an introduction to this work see page 13.

+ N.T.G.S. Data

The spectrometry and magnetics were both utilized to help in forming a local and regional interpretation of the radiometric characteristics of the various facies and the clear definition of the obscured geology.

The responses shown by the various spectrometer channels for E.L. 4856 are repeated here with much the same features apparent. There is a general lithological signature defined by the radiometrics, particularly the U/Th ratio.

No anomalies are apparent from the magnetics.

+ Gravity

The large gravity anomaly outlining the Reynolds River Granite extends south into the tenement coinciding with the interpreted subsurface location of the "Alligator Creek" Granite (informal name). It is possible that both granites are part of the same pluton which underlies a large area of the Tolmer Tabletop Plateau.

Smaller, less intense centres are located in the southeast (block 36/45) and centre (32/44). Another intense though local anomaly occurs immediately south of 30/48 (Plates 1, 5, 6 and 7).

+ Conclusions

Relating to the above geophysical surveys, the following general conclusions can be drawn which are relevant to the project area as a whole:

- (i) There are a number of granitic intrusive bodies beneath the Tolmer Sandstone probably forming ridges and troughs. Some of these are thought to have been Archaean palaeotopographic highs which, because they are along zones of structural weakness (deep seated faulting) were the locii of later granitic intrusion in late Lower Proterozoic or early Middle Proterozoic.
- (ii) The Archaean ridges existing during the sedimentation of the Lower Proterozoic sediments have acted as near-coast islands around which back reef type facies of carbonaceous and calcareous sediments have been deposited. This is clearly seen to the north at Rum Jungle and is interpreted to exist beneath the Tolmer Sandstone in various places.
- (iii) The Giants Reef Fault, a very major structural element in the Pine Creek Geosyncline, has afforded extensive related faulting and structural deformation. This can be seen from the gravity, radiometry and magnetic survey results. The Giants Reef Fault appears to trifurcate west of the northern boundary of E.L. 4858. Here it runs north as the Giants Reef Fault, NE as the Stapleton Fault and ENE as the Rock Candy Range Fault. This splitting up of the main fault (feathering) occurs at or near the point where the stratigraphic trend of the Tolmer Sandstone changes from N-S to NW-SE.
- (iv) Uranium exists within both the Lower Proterozoic and Middle Proterozoic horizons. This is shown by the U/Th ratio, the number of U anomalies and the anomalies found by ground prospection. The U/Th anomalies often occur on the western flank of the gravity anomalies, i.e. the interpreted reactivated Archaean palaeohighs. This is important to the model which implies that the uranium generated from the sediments of the Archaean (Litchfield Block) has been trapped within the back reef facies and concentrated particularly along faults active post— and pre— the deposition of the Tolmer Sandstone.
 - (v) Many faults have been defined by the U/Th and also the total count radioactivity results.
- (vi) Interpreted dolerite dykes occur particularly in the Reynolds River sheet beneath the sandstone cover. In the south they may also exist but the magnetic signature is being masked by the Cambrian and Cretaceous sediments.

+ EM INPUT Survey

This survey was flown by Geoterrex Pty Ltd. in July, 1987 and covered all tenements of the Tolmer Project. The survey was designed to cover the Tolmer Group sediments in order to located conductive features within the Lower Proterozoic Burrell Creek Formation, specifically graphitic/carbonaceous facies which occur below the unconformity.

Many conductor anomalies were found during the survey; it was attempted to identify the source of these conductors by utilizing the geological data at hand in combination with modelling based on the EM results.

Regionally, 69 flight lines for 968 line-kilometres were flown, followed by infill lines of 80 km.

The anomalies located by the survey which fall within the relinquished blocks are listed below:

Input Conductor Sheet 3:

+ 2881/2891

Located at AMG 037038 Daly River sheet, photos Run 1 4928, 4929. This INPUT anomaly was included as an additional one to investigate due to its proximity to T11 and the geological environment in which it is situated, i.e. Tolmer and Burrell Creek presence, nearby granite and the Stapleton Fault zone. The only activity on the ground was a MaxMin II survey.

A very marked EM anomaly appears on the western side of profile 1100N and extends to the northernmost section at 2000N. The conductor tends to become less apparent with increasing depth to 1300N, then becomes stronger to 1600N. From 1700N the position of the conductor switches to the west side of the grid shifting gradually to the centre until its identity is almost lost on the final profile. The conductive zone outlined by the geophysics coincides with the Alligator Creek Valley, a wide fairly flat alluvial covered area which coincides with the Stapleton Fault.

+ T23

Low priority, not followed up. The anomaly is located on Cambrian volcanics adjacent to the souther extension of the Tll glacial feature.

+ T26

A localized anomaly located within Stray Creek Sandstone. Low priority given. No ground follow-up.

3.5.3 Conclusion

The majority of relinquished blocks cover areas of non-prospective geological units - predominantly Cambrian or the upper members of the Tolmer Group. Airborne and ground prospecting methods have failed to locate anomalous zones conducive to uranium concentration. On this basis it has been decided to drop the specified areas.

3.6 E.L. 4858 INVESTIGATIONS AND RESULTS

3.6.1 Airborne Geophysics

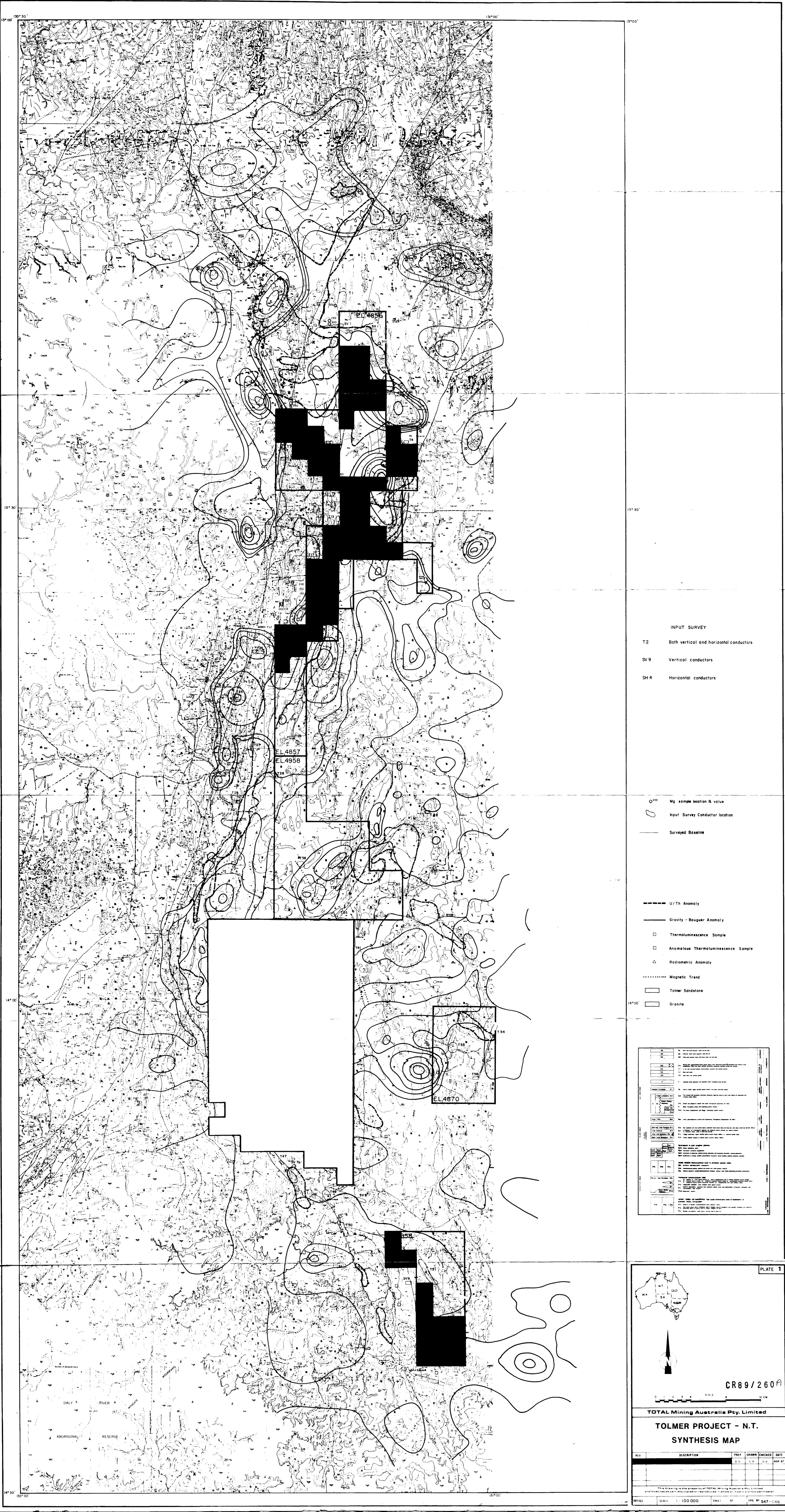
The sub-blocks relinquished were covered by a heliborne gravity survey and the following year by EM INPUT. The gravity identified the subsurface extent of the Soldiers Creek Granite where it is obscured by the Tolmer Group rocks.

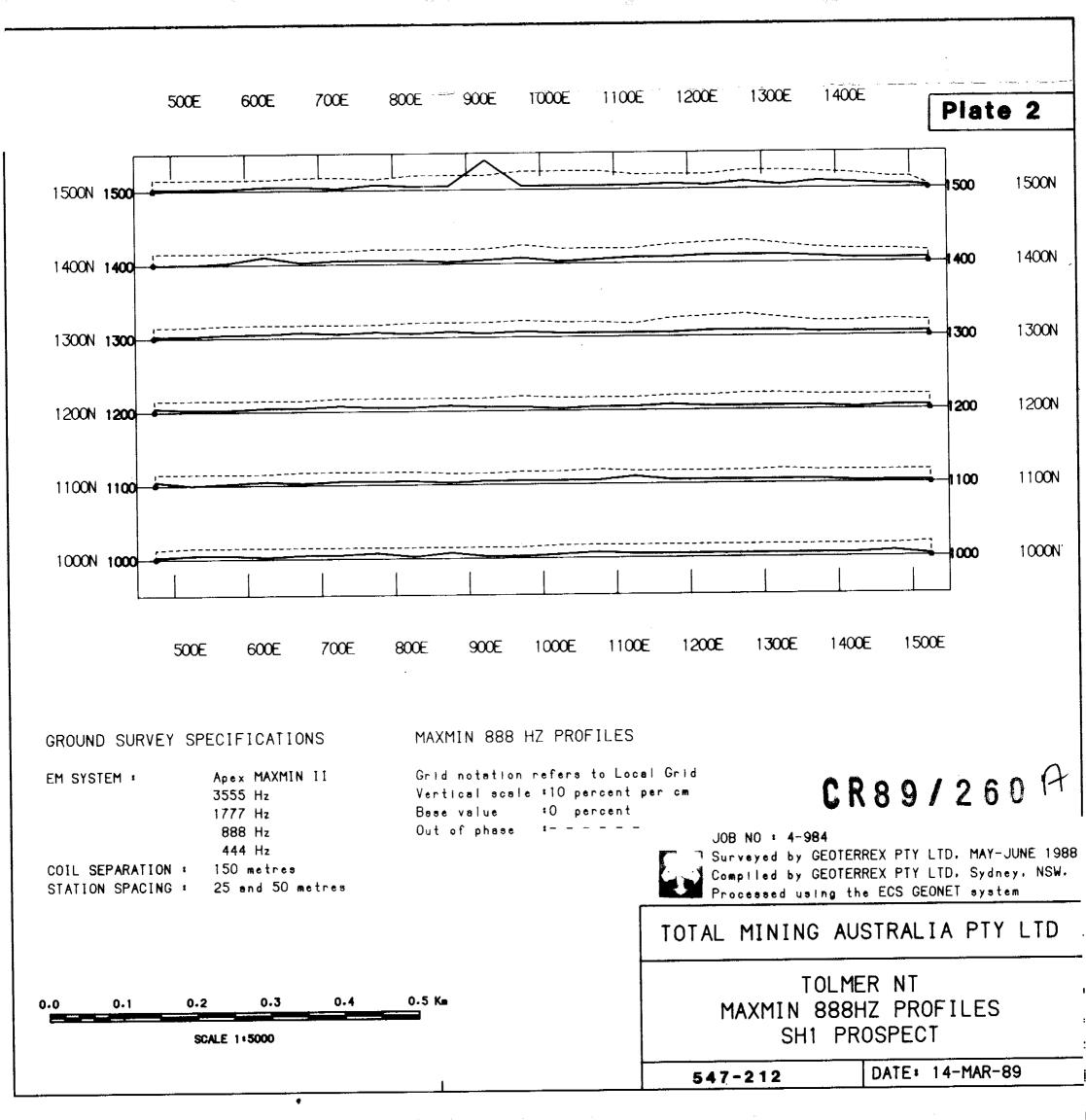
The INPUT survey outlined an elongate NW-trending anomaly which coincides with a regional lineament within Stray Creek Sandstone; this anomaly was designated as T51 (Plate 19) and given a low priority because of its lithological/structural affiliation. No follow-up was recommended. Bordering this conductor - to the east and north - is an area identified by Geoterrex as having increased conductivity. As its boundary parallels the regional strike the effect is considered lithological - probably shale/siltstone strata overlying the more resistive sandstones.

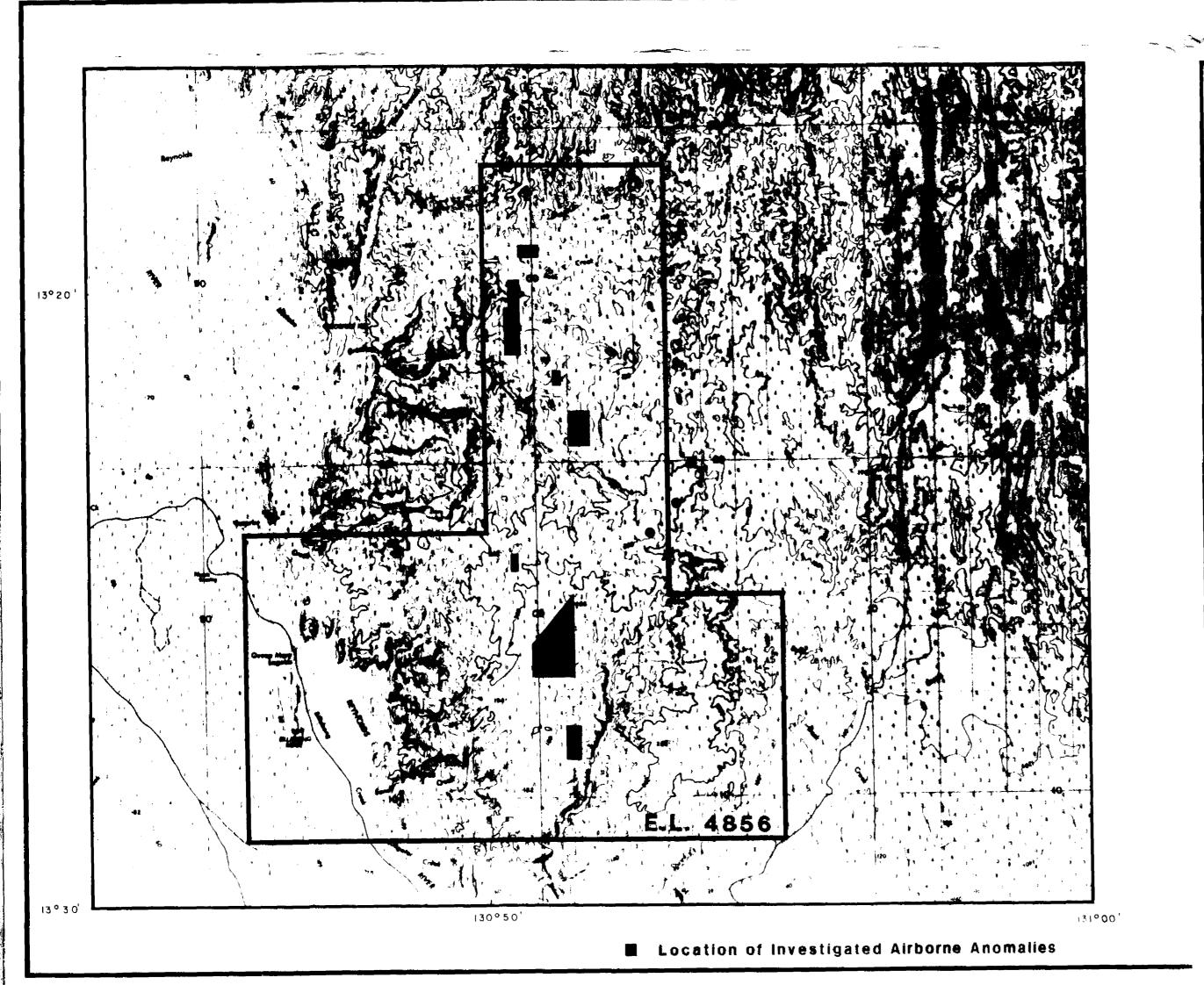
Analysis of the N.T.G.S. radiometric and magnetic data failed to outline any anomalous zones within the relinquished area.

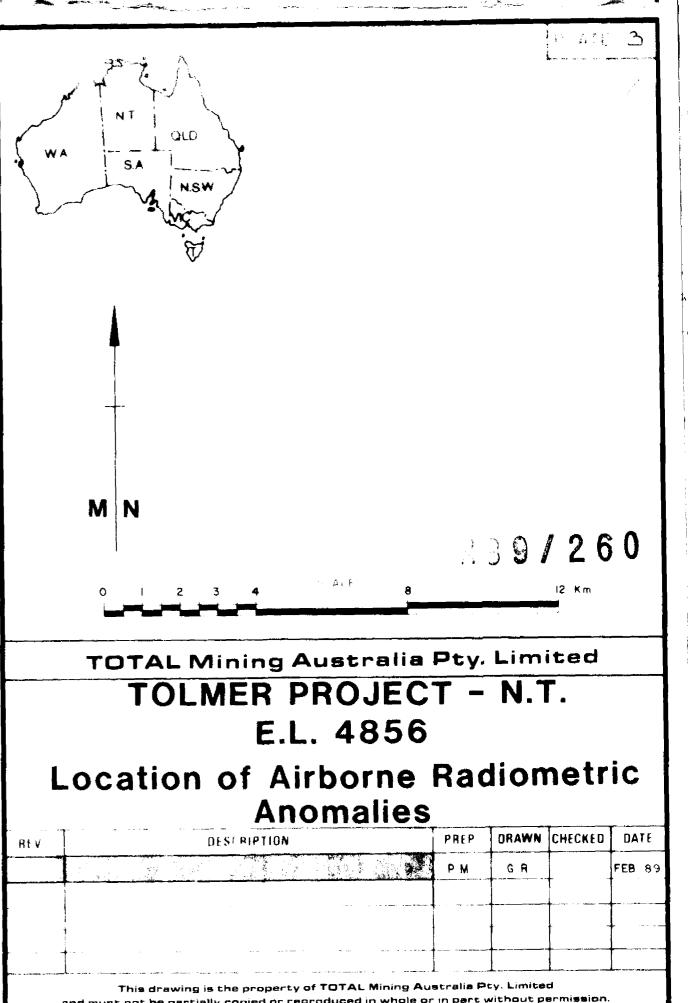
3.6.2 Conclusions

No systematic ground prospecting was carried out of the relinquished area due to its distance from the Depot Creek contact. The results of the various airborne surveys have shown that no obvious prospective targets exist and therefore it has been decided to drop the relevant blocks.









SCALE 1: 100000 SHEET

