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EXPLORATION LICENCE 1463 (WHITE HILL)

ANNUAL REPORT

YEAR ENDED 26TH JUNE, 1979.

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OPEN FILE

Distribution:

1. Marathon Petroleum Australia, Ltd., Brisbane.
2. Australian Ores & Minerals Ltd., Perth.
3. Department of Mines and Energy, Darwin.

September, 1979.

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SUMMARY

Exploration Licence No. 1463, in the Tennant Creek locality, was granted to Australian Ores and Minerals Limited on 27th June, 1978.

During the year Marathon Petroleum Australia, Ltd. took over exploration of the area under the terms of a Joint Venture Agreement that was finalized and received Ministerial approval on 13th December, 1978.

During 1978 interpretation of the regional geophysical data was carried out in conjunction with a photogeological study of the region.

Exploration of the area is continuing.

1.0 INTRODUCTION

The township of Tennant Creek is situated on the Stuart Highway approximately 500 kilometres north of Alice Springs and 1,000 kilometres south of Darwin in the Northern Territory. The semi-arid country supports semi-desert vegetation comprising porcupine bush, spinifex, turpentine bush, small eucalypts and mulga.

Gold was first recognised in the area around 1895 but it wasn't until 1932 that the first significant deposit was discovered. The field subsequently developed into a major producer of copper and gold. Only two major mines are in production at the present time; Warrego (Au, Cu, Bi, Se, Ag) and Nobles Nob (Au). One mine, Gecko, is in the development stage.

Details relevant to the geology and mineralization of various mines are presented by White (1962), Crohn (1965, 1975) Crohn and Oldershaw (1965), Wright (1965), Dunnet and Harding (1967), Large (1975) and Goulevitch (1975).

The region has been comprehensively mapped by the B.M.R. at scales of 1:250,000 (Tennant Creek sheet) and 1:63,360 (Mt. Woodcock and Tennant Creek one mile sheets).

Marathon Petroleum Australia, Ltd. are currently involved in exploration for U, Cu, Au, Bi and associated mineralization on Exploration Licences in the Tennant Creek field. As most mines are associated with quartz-hematite and/or quartz-magnetite rocks most previous exploration has concentrated on geophysical targets, especially magnetic anomalies.

2.0 LAND TITLE

Exploration Licence No. 1463, totalling 197 square kilometres in the Tennant Creek field, was granted to Australian Ores and Minerals Limited on 27th June, 1978 for a period of twelve months. A renewal application dated 30th May, 1979 was lodged with the Department, this being for the whole of the tenement area, 197 square kilometres. The first 50% reduction is due on 26th June, 1980.

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Details of the Licence boundaries are attached as Appendix 1.

During the year ended 26th June, 1979 Marathon Petroleum Australia, Ltd. carried out exploration on behalf of Australian Ores and Minerals Limited, under the terms of a Joint Venture Agreement which has been finalized and which received Ministerial approval on 13th December, 1978.

3.0 REGIONAL GEOLOGY, STRUCTURAL AND METAMORPHIC HISTORY

3.1 Regional Geology

Comprehensive reviews of the regional geology have been given by Crohn (1965), Large (1975) and Black (1977). The generalised geology is shown in Figure 1.

The Lower Proterozoic Warramunga Group forms a large proportion of the Tennant Creek Block and consists predominantly of tuffaceous greywackes, greywackes and shales with major intercalations of acid volcanics and associated pyroclastics. Estimates of the thickness of the Group range from approximately 3,000 m (Mendum and Tonkin, 1979) up to 10,000 m (Ivanac, 1954; Dunnet and Harding, 1967).

The stratigraphic succession of the Warramunga Group comprises three formations, namely the Whippet Formation, the Bernborough Formation and the Carraman Formation in order of decreasing age.

The Whippet Formation underlies the eastern part of the Tennant Creek area and consists of shallow water sandstone with subordinate amounts of greywacke and shale.

The Bernborough Formation consists of acid volcanic rocks, tuff, and tuffaceous greywacke that are interbedded with subordinate amounts of red shale and siltstone. The lower geological contact is gradational with the sedimentary rocks of the Whippet Formation, whilst the upper contact may represent a disconformity. Apart from areas occupied by resistant bedded chert, no marker horizon has been recognised throughout the volcanic sequence.

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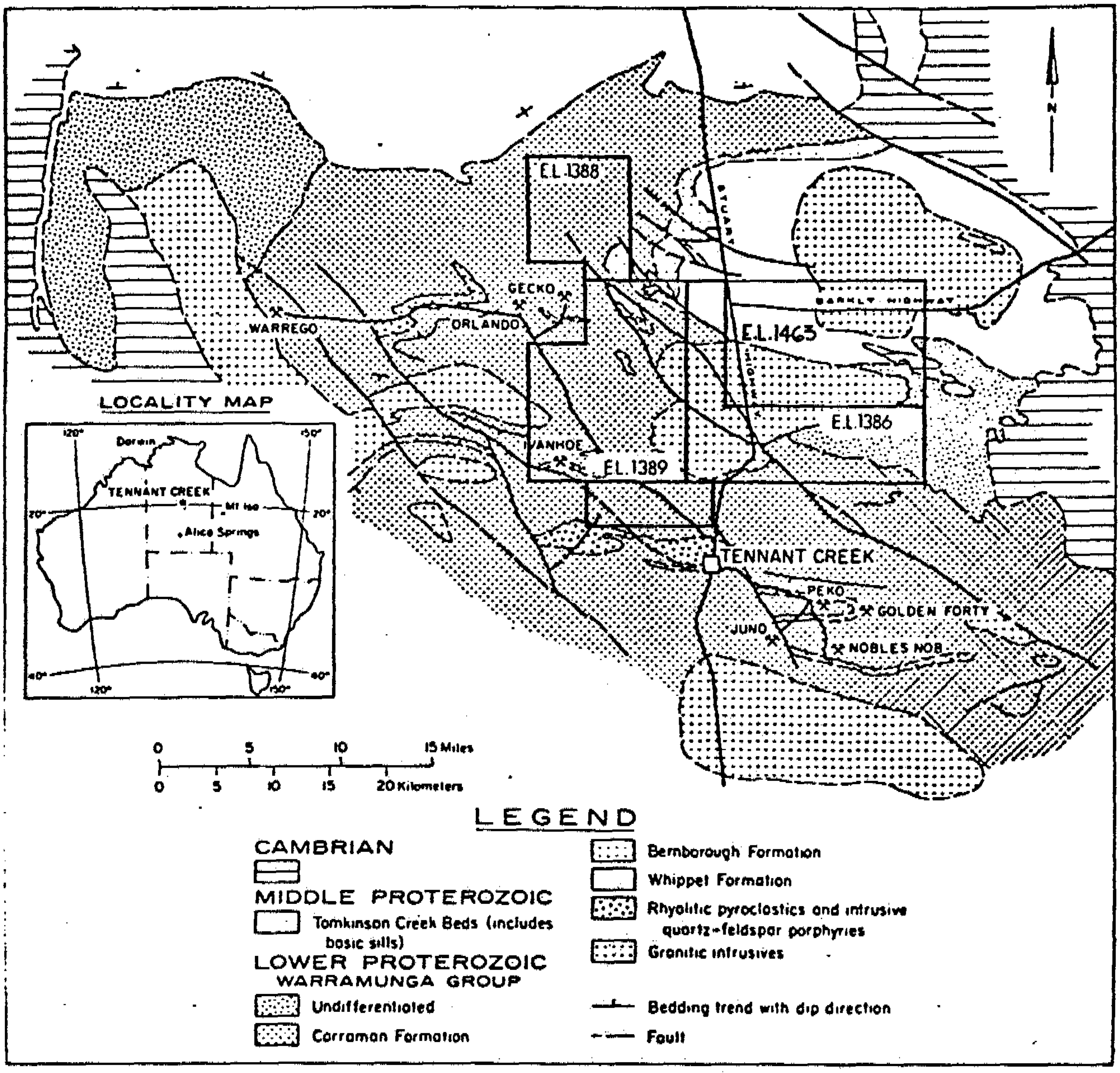

Fig. 1. Geology of the Tennant Creek goldfield with locations of producing mines.

Table 1. Stratigraphy of the Warramunga Group (lower Proterozoic)

Formation name		Lithology	Approx. thickness
			(meters)
Carraman	Iron-free facies	graywackes, lithic graywackes, and minor shales	500
	Hematite facies	felsic turbidites, tuffaceous graywackes, argillaceous iron-formations, rhyolitic pyroclastics, and ash-flow tuffs	500–1,500
	Magnetite facies	felsic turbidites, chloritic siltstones, argillaceous iron-formations	500
Bernborough		Rhyolitic lavas, pyroclastics, tuffs, and shales	0–700
Whippet		Massive sandstones, minor graywackes, and shales	300

(FROM LARGE 1975)

FIGURE - 1

The Carraman Formation forms approximately 50 percent of the outcrops in the area, and consists mainly of argillite, shale, siltstone and tuffaceous greywacke that form units with features indicative of deposition by turbidity current. Isolated occurrences of dolomite have been reported at several localities. (Dunnet and Harding, 1967, pp. 48-49).

Felsic volcanism is present throughout the formation and forms lenses that have been variously named Warrego, Orlando and Gecko Volcanics on the previous geological maps (scales 1:63,360 and 1:250,000). In the field these volcanic rocks are indistinguishable from the Bernborough Volcanics, supporting an interpretation of a pulsating volcanism during the development and evolution of the Tennant Creek basin with peak periods of volcanic activity coinciding with the Bernborough Formation and the main lenses of Orlando-Warrego Volcanics. Volcanic rocks of a fissure type are indicated to the north of Tennant Creek, where they transgress several units.

Vent areas have not been recognised with certainty in the study-area and to which extent the vents are filled with outcrops of "porphyry" is still a matter of speculation. Areas near the Tennant Creek airport and south of the Bernborough mine contain ignimbrites that could qualify as pipe fillings (Crohn, 1965).

The Warramunga Group is overlain unconformably by sediments of shallower water facies, namely the Hatches Creek Group in the south and the Tomkinsons Creek Group to the north. The Warramunga Group was intruded by granitic plutons, deformed and metamorphosed prior to the deposition of both of the abovementioned Groups.

The Hatches Creek Group (maximum thickness 7,000 m) consists of sandstone, greywacke and shale with basalt and porphyritic rhyolite present in the lower parts of the sequence (Smith et al, 1961). It has been intruded by gabbroic to doleritic dykes and sills and also by granitic plutons (e.g. the Elkedra Granite). The Tomkinsons Creek Group (maximum thickness 17,000 m) consists of quartz rich greywacke, sandstone and minor limestone, dolomite and chert. Ivanac (1954) reports rare rhyolitic porphyries and basalt. The Group is cut by basic dykes and sills, but is not intruded by granitic rocks.

The Proterozoic rocks are overlain by flat-lying Cambrian rocks and Mesozoic sediments.

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3.2 Structural History

The structural history of the Tennant Creek region is only vaguely understood. The so-called "main (east-west) folding" of Dunnet and Harding (1967) has been adopted by most authors, with the terms "east-west folding" and "main folding" being synonomous and occurring in much of the literature which has been published subsequent to Dunnet and Harding's report. Most authors regard this period of folding as the first deformational event that occurred in the region. Dunnet and Harding suggested that this main period of folding was a consequence of a second deformation and that earlier (D_1) fold structures had been folded during this event. Their evidence for D_1 was, however, limited and their discussion of that event was therefore short. Mendum and Tonkin (1979) contend that the earlier phase of folding (D_1) proposed by Dunnet and Harding did not take place.

The photo-geological map sheet of the Tennant Creek area produced by Loxton Hunting and Associates covers a large area and has been invaluable in the study of the structural history of the region. On close examination of this map-sheet it becomes obvious that the Warramunga Group sediments had been tightly to isoclinally folded (D_1) and subsequently folded (D_2) into a major open anticlinal structure. It is this open style of folding ("main east-west folding") that is considered by many workers (e.g. Black, 1977) to be the first deformational event. As most workers have not recognised this early event one should treat with caution any estimates relating to the thickness of the Warramunga Group.

The main folding event, D_2, produced a fracture cleavage (S_2) in the more massive greywacke beds and a crenulation cleavage (S_2) in the finer grained, more micaceous siltstones and shales. Partial or complete transposition of the earlier S_0 (bedding) and S_1 surfaces has been reported by Dunnet and Harding (1967) in intensely deformed areas (e.g. near the Quartz Hill fault). The low temperatures that prevailed during this period of deformation have aided in the development of the fracture cleavage and also the numerous shear zones that are roughly axial planar to the large D_2 fold.

A later event (D_3) with open folds and flexures that plunge NNW is also evident. This event has caused minor flexuring of some D_1 folds and has probably been the cause of the synclinal basins and anticlinal domes that can be observed in the northern areas of the field. This

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deformational event has been recognised by most early workers (e.g. Dunnet and Harding, 1967).

The structural position of the Tomkinsons Creek and Hatches Creek Groups is also a point of contention amongst geologists working in the Tennant Creek region. Some authors (e.g. Dunnet and Harding, 1967; Mendum and Tonkin, 1979) consider the Tomkinsons Creek Group, and by inference the Hatches Creek Group, to predate the main folding (D_2).

Other workers, however (e.g. Aust. Dev. Ltd.) suggest that the Hatches Creek and Tomkinsons Creek Groups postdate D_2. The Tomkinsons Creek Group rests uncomformably on both the Tennant Creek Granite Complex and the Warramunga Group. There is no evidence to suggest that the Tomkinsons Creek Group was folded during the first period of deformation, D_1. It has, however, been folded during D_2.

3.3 Metamorphic History

The metamorphic history of the region is also poorly understood. Some workers ascribe greenschist facies conditions (e.g. Mendum and Tonkin, 1979; Dunnet and Harding, 1967; Rao, 1977) while other workers consider the rocks to be virtually unmetamorphosed (e.g. Wyborn, in Black, 1977; Coupard, 1978). According to Duncan (1970), the composition and low structural state of K-feldspars in the porphyroidal rocks, the decalcification of andesine in the granites and the formation of chlorite and white mica in these rocks was accomplished in response to greenschist facies metamorphism. One opinion is that these conditions were attained during the first phase of deformation.

Contact metamorphic effects caused by the emplacement of the Tennant Creek Granite Complex have been mentioned by only a few workers (Crohn and Oldershaw, 1965; Dunnet and Harding, 1967). The observations made by these authors are extremely important, however, when considering the time of emplacement of this granitic complex. It is obvious that the pluton was intruded after the deposition of the Warramunga Group as it has contact metamorphosed rocks of this Group. The Tomkinsons Creek Group, however, rest unconformably on the pluton indicating that emplacement occurred prior to the deposition of this Group of sediments.

In summary it can be stated that:-

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(a) The Warramunga Group was intruded by the Tennant Creek Granite Complex and then tightly to isoclinally folded during D_1. Parallel S_1 surfaces in the sediments and the granite confirm this. Metamorphism accompanying this deformation was of low greenschist facies grade.

(b) Uplift and erosion occurred. The Tomkinsons Creek Group was deposited unconformably over the Warramunga Group and the Tennant Creek Granite Complex.

(c) During a second deformational event (D_2) the Warramunga and Tomkinsons Creek Groups were folded into broad, open anticlinal and synclinal structures.

(d) A third, weak deformational event (D_3) affected the region causing flexuring of pre-existing folds; and

(e) Cambrian strata laid down unconformably on all Proterozoic rock types.

4.0 MINERALIZATION

Comprehensive details of the geology, structure and mineralization are described in White (1962), Crohn (1965 and 1975), Crohn and Oldershaw (1965), Dunnet and Harding (1967), Large (1975) and Goulevitch (1975).

Mineralization in the Warramunga Group is widespread and consists of gold deposits associated with more massive ironstones, and copper-gold-bismuth orebodies associated with quartz-hematite and quartz-magnetite lodes and chlorite alteration.

According to Large (1977), all known economic gold, bismuth and copper mineralization in the field occurs within the Carraman Formation which forms more than 50 percent of the outcrops in the district. Large divides the Carraman Formation into three members based on the content and type of syngenetic iron oxides.

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The basal sediments of the formation, termed the magnetite facies by Large, are predominantly fine laminated siltstones and tuffaceous greywackes; the siltstones carry 2 to 15% wt. magnetite. Turbidites predominate in the upper portion, and there is sufficient volcanic material in many of the beds to warrant the term "tuffaceous greywackes". The middle section of the Carraman Formation contains a greater portion of hematite than magnetite and is termed the hematite facies by Large. The unit comprises felsic turbidites, tuffaceous greywackes, argillaceous iron formations, rhyolitic pyroclastics, ash flow and interbedded quartz-felspar-porphyry of volcanic origin. The uppermost sediments, termed the iron-free facies by Large, are predominantly greywackes and lithic wackes, with minor shales; there is a general lack of syngenetic iron oxides, and no tetsic volcanics or intrusive porphyries in this unit.

According to Large, economic gold-bismuth-copper mineralization within the Tennant Creek field invariably occurs within lenticular, ellipsoidal or pipe-like bodies rich in magnetite and/or hematite.

Seven to eight hundred ironstone bodies of various sizes occur within the Warramunga Group, but only carry economic concentrations of ore minerals when located within the hematite facies of the Carraman Formation. Within this environment, mineralized magnetite-hematite bodies are commonly found close to thin beds of argillaceous banded iron formation and hematite rich shales (e.g. Nobles' Nob, Juno and Eldorado Mines), which Large interprets as representing "normal shales which received contributions from iron-rich submarine volcanic exhalations during their period of deposition".

Other associations listed by Large include the occurrence of ore bodies within sediments adjacent to contacts of rhyolitic porphyries (e.g. Peko mine); within soft sediment slump structures such as mudflow conglomerates or breccia-conglomerate (e.g. Gecko and Orlando mines). A small proportion of mineralized ironstones, especially those with a sheet-like form, are located within faults or shear zones (e.g. Ivanhoe mine).

Mineralogy and wall rock alteration of the major mines are notably similar; massive magnetite, with minor chlorite and/or quartz, is commonly concentrated at the centre of the ironstone body. Zones composed of quartz-magnetite, hematite-magnetite, quartz-hematite, talcmagnetite,

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dolomite-jasper, dolomite-calcite, dolomite-talcchlorite, and chlorite hematite may surround the central body (Large, 1977).

According to Black (1977), geochronological studies indicate that "the concordance of muscovite ages (at 1810 m.y.) is strong evidence for a common age, and by inference, common origin for the ore deposits of at least the Warrego, Juno, Golden Forty and Nobles' Nob mines". Significantly, Black notes that so far no granites have been found to be as old as the minimum age (1810 m.y.) of the mineralization.

Ore minerals comprise gold, silver, sulphides of copper, lead and iron, sulfosalts of lead, bismuth, sellenium and copper; uraninite is known to be present in submicroscopic grains with values of over 80 ppm in the Juno ore deposit (Large, 1975, p. 1401), and monazite is present at Warrego (Goulevitch, 1975).

In addition trace amounts of sphalerite, wolframite and cassiterite have been recorded in the field.

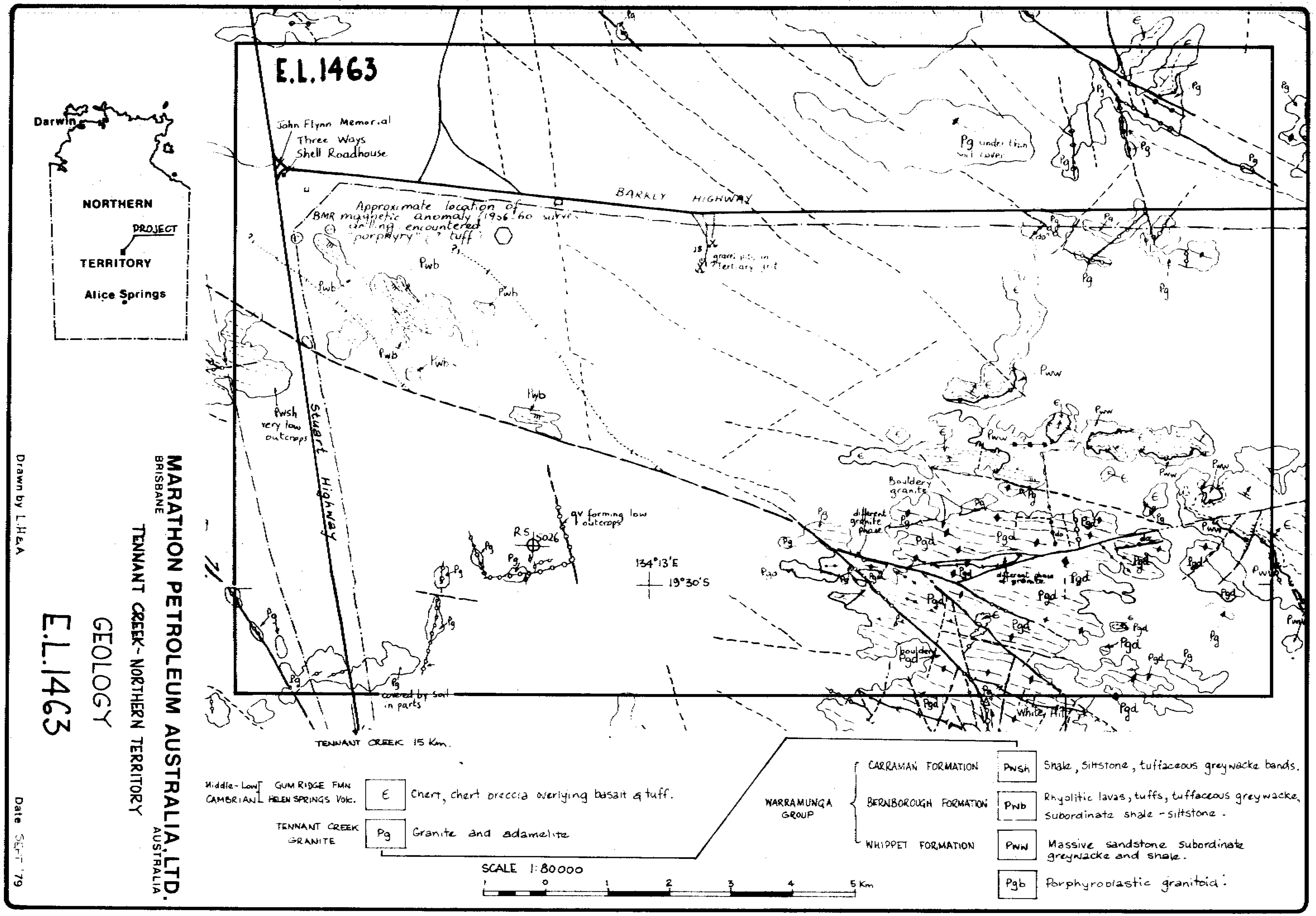
5.0 EXPLORATION

5.1 Regional Geophysical Data

All available regional aeromagnetic and spectrometer data were studied in order to determine the possible influences of regional structures on the local geology. Regional geophysical contoured maps frequently contain information regarding the presence of major regional faults and lineaments that may be important in relation to mineralization.

The B.M.R. 1:250,000 aeromagnetic compilation confirms the presence of NNW faults or discontinuities within the Tennant Creek area and also substantiates the photo-geological evidence for major ENE, ESE and NW trending faults and shears.

In addition to outlining major faults the regional aeromagnetic data also indicates the presence of distinct magnetic zones which may or may not be important in relation to areas of mineralization. Map 1 indicates some of these major subdivisions but it is stressed that this



E.L.1463
Darwin
NORTHERN
PROJECT
TERRITORY
Alice Springs
John Flynn Memorial
Three Ways
Shell Roadhouse
BARKLY HIGHWAY
Approximate location of BMR magnetic anomaly (1956-60 survey) drilling encountered "porphyry" ? tuff
gravel pits in Tertiary grit
Pg under thin soil cover
Pwb
Pwsh
very low outcrops
Stuart Highway
Pww
Bouldery granite
different granite phase
different phase of granite
qv forming low outcrops
RS 5026
134°13'E
19°30'S
Pgd
Pg
Є
bouldery
covered by soil in parts
White Hill
TENNANT CREEK 15 Km.
Middle-Low CAMBRIAN
GUM RIDGE FMN
HELEN SPRINGS Volc.
Є Chert, chert breccia overlying basalt & tuff.
TENNANT CREEK GRANITE
Pg Granite and adamelite
WARRAMUNGA GROUP
CARRAMAN FORMATION
Pwsh Shale, siltstone, tuffaceous greywacke bands.
BERNBOROUGH FORMATION
Pwb Rhyolitic lavas, tuffs, tuffaceous greywacke, subordinate shale - siltstone.
WHIPPET FORMATION
Pww Massive sandstone subordinate greywacke and shale.
Pgb Porphyroblastic granitoid.
SCALE 1:80000
1 0 1 2 3 4 5 Km
MARATHON PETROLEUM AUSTRALIA. LTD.
BRISBANE
AUSTRALIA
TENNANT CREEK - NORTHERN TERRITORY
GEOLOGY
E.L.1463
Drawn by L.Hea
Date SEPT '79

Fig. 2

interpretation of the regional magnetic data is extremely coarse and subject to revision.

5.2 Photo-geological Interpretation

A photo-geological study of the eastern part of the Tennant Creek Mineral Field using black and white vertical panchromatic aerial photographs was carried out during the period August-October, 1978 by M. Coupard of R.F. Loxton, Hunting and Associates Pty. Ltd. on behalf of the Operator, Marathon Petroleum Australia, Ltd. The study area covered about 3,200 square kilometres and included Exploration Licence No. 1463.

The aims of the photogeological interpretation were to provide as detailed a lithostratigraphic and structural map as possible, on which to base a subsequent field exploration programme designed to test exploration targets for base metals and uranium.

The photo-geological study has resulted in the empirical differentiation of eighteen discrete lithological units, nine of which correlate with the Proterozoic Warramunga Group. Of these nine Warramunga Group "units" only three outcrop in or adjacent to Exploration Licence 1463 (Fig. 2). In addition to Warramunga Group sediments and volcanics, two granite types and the flat flying Cambrian strata crop out within the limits of Exploration Licence 1463.

The degree of confidence in the recognition of these units is generally fair to poor owing to the paucity of outcrop, the poor lithological expression of individual outcrops and the sometimes fuzzy nature of the aerial photographs. In the field it was often found that the deeply weathered sedimentary and volcanic rocks possess a similar geomorphic expression and alternate rapidly in the stratigraphy. Thus the lithological units as shown on the photo-geological work sheets consist of an association of rock types with shale and greywacke predominating.

Within Exploration Licence 1463 the oldest outcropping sediments are those of the Whippet Formation. Massive quartz sandstone is the major lithotype present, however shale and greywacke occur in subordinate amounts.

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Overlying the Whippet Formation are rhyolitic lavas and tuffs of the Bernborough Formation. Minor tuffaceous greywackes, shales and siltstones are interbedded with the volcanics.

Local outcrops of Carraman Formation shales, siltstones and tuffaceous greywackes occur in the western sector of the Licence area.

The two major rock types outcropping within Exploration Licence 1463 are the Tennant Creek Granite (Pg) and a porphyroblastic granitoid (Pgb); both are of Lower Proterozoic age. The Tennant Creek Granite consists of granite and adamellite lithotypes.

Cambrian sediments overlay the abovementioned sediments, volcanics and intrusives.

5.3 Field Programme

During September 1978 a four-day programme of field checks and reconnaissance was made over Exploration Licence Nos. 1386, 1388, 1389, 1463 and 1804, by Marathon geologist, J. Clavarino, and Loxton, Hunting and Associate's geologist, M. Coupard. A total of 43 localities of particular interest with regard to the photogeological interpretation were visited, as well as various mineral occurrences and mine dumps. Final interpretation of the photogeology was completed after the field programme.

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APPENDIX 1

Description of Licence Area.

DESCRIPTION OF AREA

ALL THAT piece or parcel of land in the Northern Territory of Australia containing an area of 74.76 square miles more or less, the boundaries of which are described as follows -

Commencing at the intersection of latitude 19 degrees 25 minutes with longitude 134 degrees 12 minutes thence proceeding to the intersection of latitude 19 degrees 25 minutes with longitude 134 degrees 22 minutes thence proceeding to the intersection of latitude 19 degrees 31 minutes with longitude 134 degrees 22 minutes thence proceeding to the intersection of latitude 19 degrees 31 minutes with longitude 134 degrees 12 minutes thence proceeding to the intersection of latitude 19 degrees 25 with longitude 134 degrees 12 minutes, subject to all applications for mining tenements and excluding therefrom all mining tenements granted or registered and all reserves included within the definition of "reserve" in Section 7 of the Mining Ordinance.

APPENDIX 2

Expenditure Statement.

MARATHON PETROLEUM AUSTRALIA, LTD.

STATEMENT OF EXPENDITURE

EXPLORATION LICENCE 1463 (WHITE HILL)

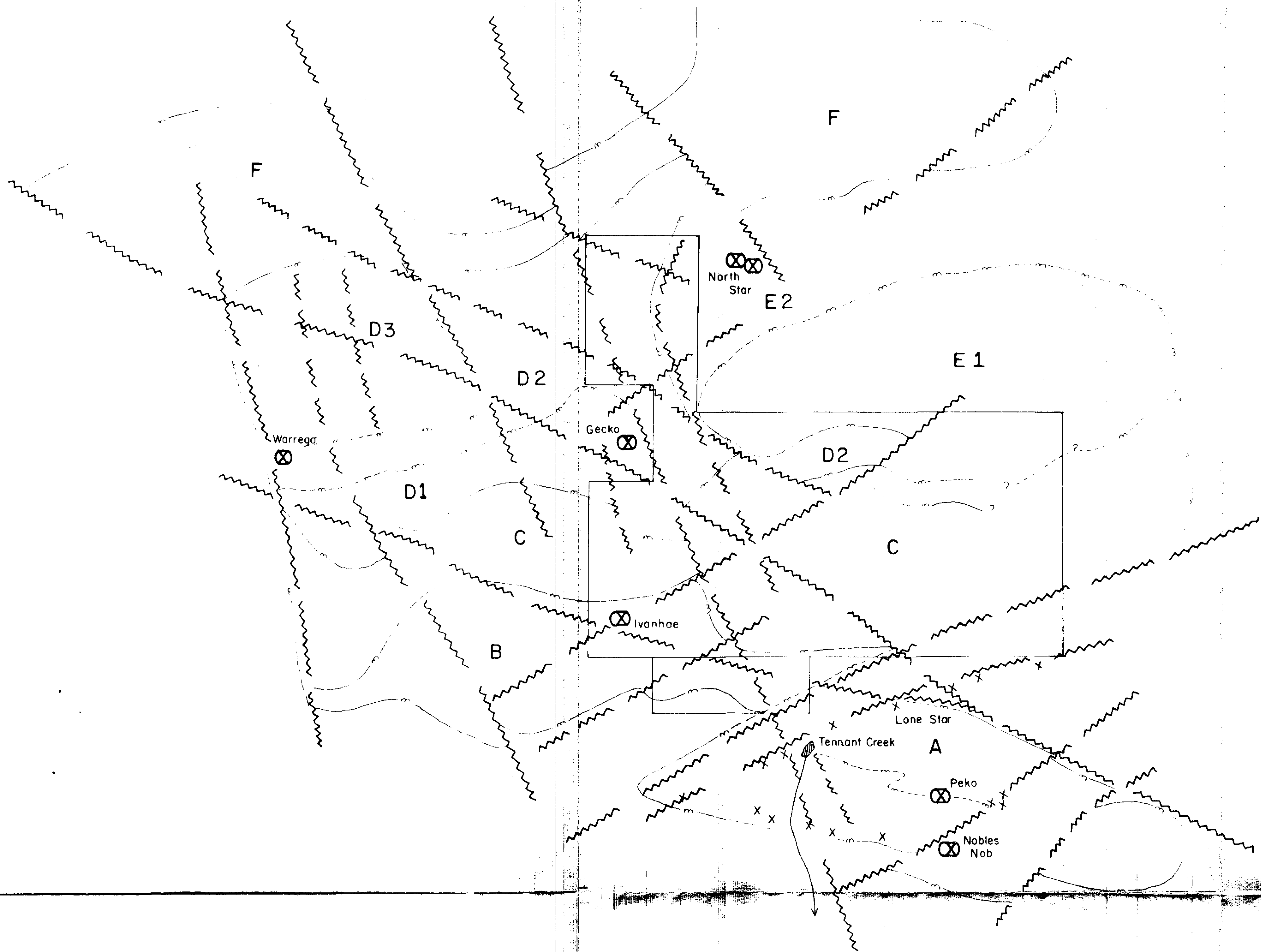
FOR PERIOD 27.6.78 TO 26.6.79.

	$
Salaries & Associated Costs	1,005.75
Business Expense	117.53
Commercial Transportation	98.04
Office Supplies	38.87
Communications Expense	34.93
Geological Services	3,783.28
Motor Vehicle Expenses	36.89
Miscellaneous	4.72
Technical Publications	170.66
Contract Services	603.83
Reproduction Expense	199.32
Freight	3.97
Camp Costs	143.99
Field Equipment Expense	91.80
Legal	454.61
Administrative Services	678.82
	$7,467.01

MAP-1

PROVISIONAL INTERPRETATION OF B.M.R. REGIONAL AEROMAGNETIC SURVEY, TENNANT CREEK.

Scale 1:250 000



LEGEND

- Boundary of magnetic zone
- Boundary within main zone
- Magnetic discontinuity (probable fault)
- Possible discontinuity or fault
- A — Reference to magnetic zone
- ⊗ — Major mine
- x — Minor occurence (largely Au)

R F Loxton, Hunting and Associates, Canberra

GA 46/78, October 1978