REPORT ON A GEOLOGICAL FIELD TRIP TO
TOBERMORY-TARLTON DOWNS AREA, NORTHERN TERRITORY

(Authorities to Prospect Nos. 2875 & 3262)

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CONTENTS

1. INTRODUCTION

2. STRATIGRAPHY
   (a) Precambrian Basement
   (b) Marqua Beds
   (c) Arrinhrunga Formation
   (d) Ninmaroo Formation
   (e) Tomahawk Beds
   (f) Kelly Creek Formation
   (g) Toko Group

3. ENVIRONMENTS OF DEPOSITION

4. CONCLUSIONS

Appendix I - Geological Cross Sections

Map 1 - Geological Map of the Marqua Area (AP 3262)
2 - Geological Map of West Marqua (AP 3262)
3 - Geological Map of the Tarlton Range (AP 2875)
4 - Geological Map of the Toko Syncline (AP 2875)
5 - Tobermory Sheet (SF 53-12)
INTRODUCTION

For the three week period from 13th August to 2nd September 1971 a field trip was made to the Tarlton Range - Tobermory area to examine and define any favourable environments in the Cambrian Georgina Basin succession for Mississippi Valley type lead-zinc-fluorite deposits. Detailed geological mapping of selected areas and many traverses were completed. Rock samples were collected for microscopic examination and chemical analysis.

Favourable environments in terms of structure, lithology, porosity and stratigraphy were located. This, coupled with the known occurrence of lead in drill core from Grp. 12 (B.M.R.) and in outcrops of the Arrinrthunga Formation further west make the area a suitable site for mineralisation. The most favourable formations within the area are the Arrinrthunga Formation, Tomahawk Beds and some horizons in the Ninmaroo Formation.

The Authorities to Prospect which cover the area are held by Fimiston Minerals N.L. (A.P. 2875 and A.P. 3262). Tobermory homestead is 180 miles from Mt. Isa and Tarlton Downs homestead is 265 miles.

This report will describe the stratigraphy, lithology and structure of the area and outline the possible palaeoenvironments that existed in Cambrian - Ordovician times in this part of the Georgina Basin.
2. STRATIGRAPHY

(a) PRECAMBRIAN BASEMENT

The outcrops of Precambrian Arunta Complex and Field River Beds in the southwest Tarlton Ranges (adjacent to the Tarlton Fault) are outside the Authority to Prospect, however the lithologies present in the Arunta outcrops are identical to a small inlier found one mile south west of Beantree Bore (abandoned) (Map 3).

This inlier outcrops as a small hill 20 - 30 feet high and covering approximately half an acre. It is composed entirely of grey meta quartzites and rounded boulders and pebbles of metaquartzite, and white vein quartz which covers the surrounding area. They are also present in the Kelly Creek Formation where it pinches out against this basement knob. This outcrop is within Authority to Prospect No. 2875.

A further significant fact is that this Precambrian outcrop lies along the axis of the major anticline in Map 3. This structure is almost certainly a draped structure formed over a basement high by compaction and varying thickness of the Cambrian - Ordovician sequence.

Near Beantree Bore the Kelly Creek Formation is in contact with the Precambrian and some slumping and small scale faulting is present in this formation along the limbs of the anticline.

To the east, the Tomahawk Beds and Arrinhrunga Formation rest directly on the basement high.

It is quite probable that in the Beantree Bore area both the Tomahawk Beds and the Arrinhrunga Formation pinch out against this basement high beneath the surface. This stratigraphic "trap" provides a suitable environment for the occurrence of stratiform lead-zinc orebodies.

In Map 1 further outcrops of the Arunta Complex occur. They are found as small outcrops along the southern boundary of the Marqua Beds (Cambrian). The contact with the Marqua Beds is a fault near Crissmas Creek dam, however to the west there is no evidence of a faulted contact and the boundary is considered to be an unconformity. This is supported by the low dips of the Marqua Beds ($3^\circ - 10^\circ$) in a direction away from the Precambrian basement.

Arunta Complex outcrops at Christmas Creek consist of gneiss and pegmatite. The pegmatite occurs adjacent to the Marqua Beds and
consists of perthitic feldspar, quartz and muscovite. Books of muscovite are up to 3 inches across and crystals of feldspar up to 12 inches long. No other minerals (such as beryl) were present in the pegmatite. The gneiss outcrops as a low ridge one mile south east of Christmas Creek Dam and on the right hand side of the road to Craigie Dam. These Precambrian outcrops are within A.P. 3262.

In Map 4 the Georgina Basin has the Craigie Fault as its southern boundary.

The fault is prominent both on air photos and on the ground. The Marqua Beds do not outcrop here and it is the Arrinthurunga Formation that is faulted against Precambrian Field River Beds. The Field River Beds consist of tillites and metaquartzites. Near the Craigie Fault shearing, fracturing and quartz veins are present.

The Arrinthurunga Formation forms a ridge adjacent to the fault.

No mineralisation was found in the Precambrian rocks during the field trip, however the importance of the Precambrian basement rocks lies in their control over depositional environments in the Georgina Basin. It appears that basement ridges (perhaps faults) have formed the anticlines in Maps 2 and 3. These anticlines provide suitable structural environments for lead-zinc deposits.

(b) MARQUA BEDS (Lower to Upper Middle Cambrian)

The Marqua Beds outcrop on Map 1 in the area south of Marqua Creek. They are a very characteristic sequence of interbedded soft white marls and thin bedded blue/grey calcilutites. The marls are soft and a white/grey colour and do not outcrop. The marl beds are 2-10 feet thick and frequently grade upward into calcilutites. The individual beds can be traced for several miles.

The calcilutites are grey to black and very fine grained and finely bedded. Near the top of the sequence there are medium-bedded units. Although finely-bedded the calcilutites form horizons 5 - 10 feet thick which are interbedded with the marls and form a rhythmic succession. The upper contact of the calcilutite sequence is sharp.

Nodules of pyrite are common in calcilutites near the top of the sequence. The pyrite has been altered to limonite/haematite while still retaining the pyrite crystal shapes. These nodules are up to one inch in diameter.

The Marqua Beds south of Old Marqua bore dip 15° to 355°, however eastward towards Christmas Creek they become folded. The style
of folding is illustrated in photos 14, 15. The folds have straight limbs and there is a narrow hinge and they plunge 25° - 300°. At Christmas Creek the beds have thinned considerably and are vertical striking to O80°.

Some brecciation has occurred here and the beds unconformably overlie a quartz/feldspar/muscovite pegmatite 200 yards south of Christmas Creek dam.

Immediately north of Christmas Creek Dam the Marqua Beds are unconformably overlain by the basal units of the Arrinhtumga Formation. The section measured south of Old Marqua bore was 850 feet thick. The section can be divided into three units:

Unit 3: 110 ft. Calcareous Sandstone and Flaggy blue/grey limestone:
The calcarceous sandstone is brown and buff, medium-grained, flaggy, with some calcarenite beds.

Unit 2: 650 ft. Calciiulite: blue, fine-grained, medium and thin bedded, interbedded with marls. Pyrite nodules in some horizons.

Unit 1: 90 ft. Shale: buff, white, hard, silicified, thin-bedded.
7 ft. Blue chert.

Except for the basal band of blue chert the lower units do not outcrop strongly. Near Christmas Creek the sequence thins to 450 feet consisting entirely of Unit 2. Unit 1 may pinch out in the subsurface while unit 3 is probably overlapped by the Arrinhtumga Formation.

The Marqua Beds also outcrop south of Map 3 (south-east of the Tarlton Range) and here the blue-black finely laminated calcilultites have a petrolierous odour when freshly broken. This outcrop is outside the A.P. although the beds persist in the subsurface to the north. The sandstone of unit 3 occurs in B.M.R. 12, (2,721 - 2,790 ft.) as a porous calcareous sandstone and sandy and argillaceous limestone.

The samples collected from the Marqua Beds, in stratigraphic succession, are as follows:

286 Grey calcilultite
287 Laminated finely crystalline calcarenite
288 Grey banded calcilultite
289 Laminated calcareous siltstone
290 Laminated yellow brown calcilultite
292 Finely laminated grey calcilultite
293 Yellow grey calcilultite
294 Finely laminated grey calcareous siltstone
297 Laminated yellow grey calcilultite
(c) ARRINTHRUNGA FORMATION (Upper Cambrian)

The Arrinthunga Formation was examined where it outcrops as low ridges on the eastern and south eastern area of Map 3; as more prominent ridges in Map 2; covering a large area of Map 1 and along the Craigie Fault in Map 4.

From studying the lithology and stratigraphy of outcropping Arrinthunga Beds and comparing it to the cores from B.M.R. Grp. 12 which have been examined, it is possible that the interval below 700 feet in Grp. 12 (in which galena was found at 734 feet) belongs to the Arrinthunga Formation rather than the Tomahawk Beds as stated in B.M.R. Record 1963/68.

The Arrinthunga Formation also contains galena mineralisation at the surface near Box Hole Bore (Wolley & Rochow 1961) which is west of the Tarlton Range on the Hückitta Sheet.

The Arrinthunga Formation contains the most favourable strata for lead/zinc mineralisation in the area examined and it is known to extend northward into the basin beneath the Ninmaroo and Tomahawk Beds.

The Arrinthunga Formation can be divided into four units and this is done on Maps 1 and 2. However only the basal unit is exposed on Map 3. Here it is flat lying and is probably onlapping the Precambrian and Marqua Beds, which it overlies unconformably (seen in Map 1). The basal unit is also exposed in the core of the major E. – W. anticline on the extreme eastern edge of Map 3.

On Map 2, Units 1 and 2 are recognisable in two anticlines and here dips of up to 20° are common. The outcrop is not good here and the complete structure was not determined. It is possible that the hinge of another anticline occurs south of the mapped outcrop.

North of Black Tank (Map 1) the four units of the Arrinthunga Formation are exposed.

Unit 4: Brown dolomite beds (2–3 feet thick) interbedded with thin bedded calcereous quartz sandstone, red and green glauconitic siltstone and some marls and blue oolitic limestone. The outcrop is generally poor and cannot be traced on airphotos. Approximate thickness is 200 feet.

Unit 3: Brown calcarenites and thin to medium bedded dolomite and limestone with interbedded marls breccias and siltstones. The dolomites and limestones outcrop strongly and can be traced on airphotos. The bedding becomes less evident on the airphotos towards the top. Approximate thickness 300 feet.
**Unit 2:** This is the most obvious unit and is a regular bedded sequence of oolitic limestones, fine bedded dolomites, intraformational breccias and minor siltstone. The beds are 1 - 2 foot thick and can be traced for several miles. Porosity is good in several beds. Approximate thickness 500 feet.

**Unit 1:** Outcrop is strong due to the thick beds of hard brown dolomite and oolitic limestone. Some of the dolomite has algal-like structures. The basal part of this unit is a brown calcareous quartz sandstone with cross-bedding. The dolomite overlying this sandstone is porous (vughs up to 1 inch in diameter). Approximate thickness 100 feet.

Tectonic folding occurs in the Arrinhrunga Formation north of Christmas Creek dam. This folding was also observed in the Marqua Beds. A major syncline and anticline were mapped in units 2 and 3. The plunge of the anticline varies but is approximately 12° to 260°.

The outcropping section of the Arrinhrunga Formation to the west (north of Marqua homestead on Map 1) is either flat lying or only gently dipping 3° to 005°. In this section units 2 and 3 appear to be missing or considerably thinner. Unit 1 extends on the surface for approximately 2 miles north of the homestead, followed by beds characteristic of unit 4 for a further 2 miles.

To the east in Map 4 only unit 2 is exposed. The beds are vertical (striking 120°) and adjacent to the Craigie Fault.

In Map 4 there is a distinct disconformity between the Arrinhrunga Formation and overlying Ninmaroo Formation. In other areas the upper boundary of the Arrinhrunga Formation is not sufficiently exposed however the draped anticline (in Map 3) over a basement high suggests that units of this Formation pinch out beneath the overlying strata on the flanks of the anticline.

**In summary** the Arrinhrunga Formation consists mainly of limestone and dolomite with several oolitic beds and some algal type structures. Fine grained, creamy brown, laminated siltstone and dolomite breccia is interbedded with the limestones and dolomites. More fine grained beds occur in unit 3 compared to unit 2, while sandstones and calcarenites are more common in units 1 and 4. The carbonate rocks are generally grey, cream and brown. The majority of beds are one foot to three foot thick but they become thicker in units 1 and 4. Porosity is medium to high, and is particularly good in units 1, 2 and 4.
Samples from area of Map 1.

Unit 1

237 Dolomite
239 Yellow grey calcilutite
240 Yellow grey calcilutite with calcite veining
241 Grey calcarenite
242 White calcarenite
243 Grey calcilutite
245 Breccia with calcilutite fragments
246 Yellow grey calcilutite with haematite/limonite nodule in calcite vein
247 Grey calcilutite
248 Grey weathered vuggy oolitic dolomite
250 Yellow grey finely crystalline calcarenite

Unit 1 to west of Map 1

298 Yellow brown vuggy dolomitic calcilutite
299 White calcilutite
300 Finely crystalline orange brown calcarenite
301 Yellow extensively recrystallised oolitic calcarenite (like calcilutite in hand specimen)
302 Yellow brown oolite
303 Yellow coarsely crystalline calcilutite
304 Yellow white recrystallised calcilutite
303 Dark yellow banded vuggy calcilutite
307 Yellow brown vuggy coarsely crystalline calcilutite
309 Yellow brown calcilutite
310 Calcarenite and calcilutite with some quartz sand
312 Finely banded yellow brown calcilutite
313 Laminated fine grained calcareous sandstone
314 Finely crystalline vuggy calcarenite
315 Yellow grey vuggy recrystallised calcilutite
316 Light porous calcareous sandstone
317 White calcareous sandstone

Unit 1 - Immediately east of the Marqua Monocline Map 1

327 Yellow brown recrystallised dolomitic calcarenite
328 Yellow oolitic calcareous sandstone

Unit 2 - Old Marqua Area Map 1

251 Yellow brown calcilutite
252 Yellow brown calcilutite
253 Yellow recrystallised calcilutite
254 Grey recrystallised calcarenite
255 Yellow brown dolomitic calcilutite with calcite veining
256 Yellow brown calcilutite
Yellow brown coarsely crystalline calcilitute
Yellow brown coarsely crystalline calcilitute
Yellow brown banded calcilitute
Grey calcilitute
Yellow grey calcilitute
Coarsely crystalline yellow brown calcilitute
Yellow brown calcilitute
Grey calcilitute
Yellow brown recrystallised calcarenite
Yellow and grey banded calcilitute
Yellow brown banded calcilitute
Yellow brown dolomitic calcilitute
Yellow brown recrystallised oolitic calcarenite
Yellow recrystallised calcarenite
Yellow brown banded calcilitute
Yellow and grey banded calcilitute

One sample slightly west of above traverse

Yellow brown oolite

Unit 2 - Eastern Part of Map 1, near Craigie Fault

Glaucnatic fossiliferous recrystallised calcarenite with crinoid fragments
Recrystallised coquinite
Grey black dolomitic calcarenite recrystallised and with iron stain?
Calciurudites, dolomitic breccias and porous limestones also occur here.

Unit 3 - Old Marqua Map 1

Recrystallised calcarenite
Grey calcareous laminated siltstone
Yellow white calcilitute
Calcareous sandstone with calcite veining
Banded calcirudite with oolitic calcirudite
Finely laminated yellow brown calcilitute

Unit 4 - West Section of Map 1, 4 miles North of Marqua Homestead

Yellow grey calcilitute
Orange grey calcilitute

Map 2 Arinthrupu Formation

Breccia
Yellow brown calcarenite with calcite veins
Light brown vughy coarsely crystalline dololutite
354 Yellow brown coarsely crystalline calcilutite
355 Yellow brown vughy calcarenite
356 Silicified yellow grey vughy calcilutite with iron stain on margins of vughs
357 Yellow white vughy recrystalised coquinite

North of Above Section

342 Yellow grey vughy coarse crystalline calcilutite
343 Coarsely crystalline vughy yellow brown calcilutite
344 White recrystalised calcarenite
346 Fine crystalline yellow brown calcarenite
348 Calcareous sandstone and muscovite mica
349 Yellow calcareous sandstone
350 Yellow brown calcilutite

2 Miles to 095° from Southern Dam Map 3

62 Yellow brown silicified vughy dolomitic calcilutite
63 Yellow brown recrystalised oolitic calcarenite
65 Breccia - calcilutite cement with calcilutite fragments - some silicification
66 Dark yellow brown tight dolarenite

½ Mile Further East

67 Yellow brown vughy dolomitic calcarenite
68 Yellow brown finely crystalline vughy calcarenite
69 Yellow brown calcilutite
70 Yellow brown finely crystalline calcarenite

104-107 Along Old Marqua Tarlton Downs Boundary Fence

104 Yellow brown calcarenite
106 Light yellow recrystalised calcarenite
107 Yellow recrystalised calcarenite
(d) **NINMAROO FORMATION** (Late Upper Cambrian - Lower Ordovician)

The Ninmaroo Formation is considered to be laterally equivalent to the lower Tomahawk Beds and outcrops over a large area of the Authority to Prospect. The lithology is mainly calcarenite, dolarenite, limestone, oolitic limestone and dolomite with siltstone and calcilutite in some areas (Map 4).

The section measured in Map 4 was approximately 1,000 feet. Here the beds form the western flank of the Toko Syncline and they dip 4° - 20° generally in a north east direction. However, the area is complicated by severe slumping of the beds in the area between Burnt Well and the Craigie Fault (Map 4). The slumping is both on a small and large scale. Neither the underlying Arrinthurunga Formation, nor the overlying Kelly Creek Formation have been affected by slumping.

To the north where the Ninmaroo Formation outcrops in A.P. 2875 the beds are flat lying and it is not possible to measure a complete section. However in this area well jointed limestones, dolomites and calcarenites outcrop. The joints are vertical and trend to 280° with a minor set trending north-east. The formation extends to 485 feet below the surface in B.M.R. 12.

The jointing, particularly if it persists at depth increases the permeability of the beds and would provide favourable sites for mineral deposition.

The contact between the Ninmaroo Formation and the underlying Arrinthurunga Formation is disconformable where it can be observed in Maps 1 and 4 while the overlying Kelly Creek Formation is conformable.

In the area near Umenumbera Hills and Beerleigh Bore there is a lateral gradation westerly from Ninmaroo Formation to the lower Tomahawk Beds. It is not possible to define the boundary, however the gross lithology changes from more massive calcareous rocks in the east to interbedded calcarenites, dolomites, calcilutites and glauconitic sandstone in the Tomahawk Beds.

The Ninmaroo Formation has been divided into 4 members in some areas, however these were not recognisable on the surface in the areas examined.
Samples collected from the Ninmaroo Formation 8 miles north of Marqua Homestead.

324 Recrystallised yellow brown dolomitic calcilutite
325 Yellow brown coarsely crystalline calcarenite
326 Grey calcilutite

5 Miles North of Craigie Dam

333-339 Thin bedded calcareous siltstone, calcarenites, and calcilutite
383 Silicified calcareous sandstone
334 Yellow oolitic calcarenite with calcite veining
335 Fine grained orange brown calcarenite
336 Recrystallised yellow brown oolite
337 Grey recrystallised calcilutite with shell fragments?
339 Recrystallised glauconitic oolite with calcilutite blebs.
(e) TOMAHAWK BEDS (Upper Cambrian - Lower Ordovician)

The Tomahawk Beds outcrop in the western part of the Authorities to Prospect and consist of green shale, grey siltstone, inter-bedded with dark brown and grey brown dolomite, grey limestone, calcarenite and minor sandstone. It appears that this area of outcrop contains a greater, although variable from section to section, amount of carbonate when compared to the more terrigenous detritus deposited to the north west of the Tarlton Range (Smith 1967).

The basal units are not exposed so it is not possible to determine the nature of the contact with the Arrinthurunga Formation. The contact has been found to be both conformable and unconformable on the Huckitta Sheet to the west.

The beds form extensive sheets of flat lying sediments along the eastern margin of the Tarlton Range and are well exposed in creeks and along ridges.

Two important anticlines are found in the Tomahawk Beds in the south-east part of the Tarlton Ranges. Both anticlines strike approximately east-west and both appear to be drape structures rather than tectonic features. The outcrop of Precambrian quartzite in the core of the anticline near Beantree Bore is evidence for this. Two miles east of Beantree Bore slumping occurs on the southern flank of the anticline, however it is generally within calcilutite beds that are 1 - 3 feet thick.

The anticline can be traced east from Beantree Bore across Map 3 and continues as an anticline in the Arrinthurunga Formation (Map 2). The hinge appears to be horizontal although a gradual plunge to the west may be present. Dips of 2° - 4° occur along the limbs.

Immediately north of Mulga Bore the oldest beds outcrop in the core of the anticline and consist of recrystallised oolitic limestone. On the northern flank of the anticline near this location a limestone/dolomite breccia outcrops.

One mile south of Mulga Bore a second, smaller anticline occurs trending east-west, but can only be traced for approximately two miles. This anticline plunges 2° - 3° to the east and the stratigraphically lowest beds exposed are recrystallised oolitic limestones and dolomites with calcarenites. These beds are overlain by glauconite siltstones, shales and calcilutites and also grade laterally into similar lithologies. Along the northern flank of the anticline and particularly
in the east slumping has occurred in the thinly bedded siltstones, shales and lutites. Here vertically dipping beds occur. Pyrite was found in dolomite and calcarenate (sample location 32 - 41).

Five miles south of Mulga Bore (sample location 155 - 167) a brown-buff dolomite outcrops and contains veins up to 2 inches across of crystalline white calcite. Samples from this locality also contain some black bituminous material.

Samples collected from traverses across anticline between Beantree Bore and New bore:-

15 Fossiliferous glauconitic calcarenate
16 oolitic dolarenite
17 Yellow brown oolite
18 Recrystalised yellow brown dolomitic oolite
75 Yellow brown oolitic calcarenite
76 Recrystalised fine grained oolite
78 Recrystalised oolite
79 Yellow grey oolitic dolomitic calcarenite
81 Silicified banded recrystalised oolite
209 Brown recrystalised vuggy dolomitic calcarenite
210 Coarsely crystalline orange brown oolitic calcarenite
211 Finely crystalline orange brown oolitic calcarenite
212 Yellow brown vuggy coarsely crystalline dolomitic calcarenite
214 Coarsely crystalline recrystalised dolomitic calcarenite with calcite veining
215 Yellow brown glauconitic fossiliferous recrystalised calcarenite
216 Glauconitic recrystalised dolomitic calcarenite

6 Miles West of Mulga Bore

187 Light yellow brown calcarenite
188 Yellow brown oolitic calcarenite
189 Dolomitic oolitic yellow brown calcarenite
190 Yellow brown calcarenite
191 Yellow brown vuggy dolomitic calcarenite
192 Yellow brown recrystalised dolarenite
193 Glauconitic recrystalised calcareous sandstone
194 Yellow brown glauconitic calcarenite with calcite veins.

Calcite pods occur in vughs in dolomites. Beds are slumped in this area.
2 Miles South West of Mulga Bore

Samples are from a section through the anticline south of Mulga Bore.

217 Yellow brown finely crystalline calcarenite
219 Yellow brown recrystallised dolomitic calcarenite
220 Greenish grey glauconitic calcarenite
221 Yellow grey oolite
222 Yellow brown finely crystalline calcarenite
224 Coarsely crystalline glauconitic calcarenite
225 Yellow brown calcarenite
226 Two samples of this number
   (a) finely crystalline yellow brown calcarenite
   (b) brecciated calcilutite with calcarenite cement
227 Grey calcilutite
228 Yellow brown calcilutite
229 Recrystallised glauconitic oolite
234 Calcareous sandstone

195-207 Sequence through anticline near Beantree Dam

195 White recrystallised oolitic calcarenite
197 Yellow brown recrystallised oolite
198 Grey white fossiliferous calcarenite
199 Coarsely crystalline calcilutite
200 Yellow brown recrystallised oolite
201 Yellow brown recrystallised oolitic calcarenite
203 Porous calcareous sandstone
204 Yellow brown recrystallised oolite
205 Finely crystalline calcarenite
206 Yellow brown vughy calcilutite
207 Yellow recrystallised calcilutite

Traverse two miles south east of Mulga Bore across anticline.

109 Yellow brown glauconitic bituminous calcarenite
110 Glauconitic oolitic dolomitic calcarenite
112 Recrystallised vughy oolite
113 Fine grained calcareous sandstone
116 Yellow brown dolomitic oolite
117 Very porous light white calcareous sandstone

The anticline is exposed in the creek along the line of the traverse. Lithologies also include thin bedded sandstones, shales, marls, calcarenites and breccias.
Traverse due south of Mulga Bore.

48 Laminated calcareous micaceous sandstone
52 Iron cemented? calcareous sandstone
54 Iron stained red brown dolarenite
55 Recrystalised oolite
56 Light yellow brown crystalline dolarenite
57 Yellow brown vughy oolite
58 Yellow brown recrystalised oolite
59 Fine grained glauconitic oolite
60 Dolomitic vughy oolite
61 Glauconitic calcareous sandstone

Traverses on the southern limb of anticline 2.6 miles south west of Mulga Bore.

28 Black dense calcarenite
29 Recrystalised vughy dolomitic calcarenite
30 Yellow Brown vughy oolite
31 Silicified oolite with vugh fillings of chalcedony

3 miles south of Mulga Bore.

71 Yellow brown recrystalised dolomitic oolite
72 Recrystalised oolite
73 Recrystalised dolomitic oolite
74 Red brown oolite (iron stain)

Samples collected 4 miles south west of Mulga Bore. Lithologies include thin beds of green shale and calcilutite overlain by thick beds of calcarenite. Some pyrite present.

32 Yellow and brown spotted coarsely crystalline recrystalised dolomitic calcarenite
33 Coarsely crystalline recrystalised calcarenite with calcite veins
34 Grey yellow spotted recrystalised calcarenite
35 Coarsely crystalline dolomitic calcarenite
36 Coarsely crystalline grey glauconitic fossiliferous calcarenite.
Fossil fragments include the pygidium of an asaphid trilobite.
37 Recrystalised glauconitic oolitic dolomitic calcarenite
38 Recrystalised oolitic calcarenite
39 Recrystalised calcarenite
40 Breccia
41 Light Grey oolitic calcarenite
5 miles south of Mulga Bore, sequence 121-129 includes thick bedded dolomites, fossiliferous calcarenites and calcirudites.

121 Yellow brown recrystallised oolitic dolarenite
122 Red brown recrystallised oolite
123 Banded calcarenite and calcilutite
124 Yellow brown oolite
125 Brown oolitic fossiliferous calcarenite
127 Recrystallised dolomitic oolitic calcarenite
128 Recrystallised dolomitic oolite
129 Recrystallised fossiliferous oolitic dolomitic calcirudite

130 to 142 includes thick bedded limestone and dolomite, minor green shale and calcarenite.

130 Silicified glauconitic fossiliferous calcareous sandstone with some quartz sand.
131 Brown recrystallised oolite
136 Recrystallised yellow brown oolite
137 Brown black yellow mottled vughy oolitic calcarenite
138 Yellow brown fine crystalline dolomitic calcarenite
139 Yellow brown recrystallised oolite
140 Recrystallised glauconitic oolitic calcarenite
141 Oolitic calcarenite
142 oolite

143 - 154 include banded grey brown dolomites in beds up to 4 feet thick, coquina, calcarenite, green shale, calcilutite forming thin beds and calcirudites containing limestone boulders.

143 Recrystallised yellow brown oolite
144 Fine grained recrystallised oolite
147 weathered calcarenite
148 Brown yellow recrystallised oolite
149 Recrystallised yellow brown oolitic? dolomitic calcarenite
150 Grey yellow recrystallised oolite
151 Yellow brown recrystallised oolite
152 Recrystallised oolite
153 Yellow brown calcarenite
155 - 167 small outcrop surrounded by alluvium, veins of coarse calcite and brown dolomite.

155 Yellow brown banded finely crystalline oolitic calcarenite
157 Dark yellow brown vughy dolarenite with calcite veins.
158 Recrystallised yellow brown dolarenite
159 Fossiliferous oolitic calcarenite
160 Yellow brown dolarenite with calcite veins
162 Yellow grey recrystallised oolitic calcarenite
Yellow brown recrystallised dolomitic oolite
Recrystallised dolarenite with calcite veins
Clayey dolomitic calcarenite

1 mile west of Southern Dam

Yellow brown glauconitic calcarenite with some quartz
Recrystallised dolarenite
Recrystallised vughy dolomitic calcarenite
Yellow brown recrystallised dolomitic calcarenite
Very vughy dolarenite
Yellow brown vughy dolarenite
Recrystallised vughy dolomitic calcarenite
Yellow brown recrystallised dolomitic calcarenite
Yellow brown recrystallised dolomitic calcarenite
Yellow brown vughy recrystallised dolarenite
Porous cream glauconitic calcareous sandstone

2 miles N.E. of Lucky Bore

Oolitic glauconitic calcirudite with calcilutite fragments
Yellow grey glauconitic calcarenite
Yellow brown recrystallised calcarenite

82-91 Map 5 north of Map 3 boundary. Bioturbated siltstone at base, interbedded limestone and thick bedded quartz sandstone

Calcereous glauconitic sandstone with some quartz
Porous calcereous sandstone
Calcereous sandstone with some quartz

Map 5 near eastern bore
92-98 massive limestones and dolomites

Calcereous sandstone
Oolitic dolomitic calcarenite
Yellow brown recrystallised oolite
Recrystallised dolomitic oolite
Yellow brown oolite
Yellow brown recrystallised oolite
Yellow brown recrystallised oolitic dolarenite

99-102 south of Eastern Bore. Pebbly dolarenite overlain by calcereous sandstone

Fossiliferous oolite, fossil fragments include asaphid remains
Fossiliferous oolitic calcarenite
Recrystallised fossiliferous oolitic calcarenite, fossil fragments include an asaphid pygidium.

2 miles east of Eastern Bore (Map 5). Banded recrystallised yellow brown calcilutite and shelly limestone.
(f) KELLY CREEK FORMATION (Lower Ordovician)

The Kelly Creek Formation outcrops both in the west (Map 3) and in the east (Map 4).

The lithology consists of flaggy iron stained quartz sandstone, siltstone, some calcareous sandstone and calcarenite with fossiliferous white chert occurring in the upper beds near Coolibah Dam (Map 4).

Good outcrops were examined along the scarp on the eastern side of the Tarlton Range (Map 3) and in isolated mesas near the south-eastern end of this Range. Here some beds of sandy dolomite and calcarenite are interbedded with the sandstones. Glaucunite is common in many beds. The formations crops out well in several benches, which can be followed for several miles along the scarp of the Tarlton Range. North of Map 3, the Kelly Creek Formation grades laterally into the Tomahawk Beds, however in Map 3 there is quite a distinct boundary between the rock units.

The sequence in the Tarlton Range (Map 3) is considerably thinner than in the Toko Range (Map 4), most sections being approximately 250 feet thick as compared to 600 feet.

The beds of the formation are gently dipping to flat lying in Map 3 except near Beantree Bore where they form an anticline over a basement high with some slumping along the flanks.

In the Toko Range (Map 4) the beds dip gently (3° - 8°) north east towards the Toko Syncline.

The Kelly Creek Formation is not considered to be of interest for stratiform type lead-zinc deposits although it is important in reconstructing geological environments during the Ordovician - Cambrian.

Samples collected from the Kelly Creek Formation:

23  Cross bedded sandstone
24  yellow porous calcareous sandstone
25  Banded calcareous sandstone with some quartz
27  (Map 5) interbedded calcarenite, calcilutite and sandstone
44? 1 mile south west of Beantree Dam, oolitic limestone, Recrystallised oolite
(g) **TOKO GROUP** (Lower - Middle Ordovician)

The Toko Group has been divided into four units, all of which crop out in the Toko Range and three of which crop out in the Tarlton Range. In ascending order they are:

1. **Coolibah Formation**

   This formation was not recognised in the Tarlton Range. The type area for the Coolibah Formation occurs within Map 4 on the road from Craigie Dam to Tobermory homestead and was examined in the field. The formation in the type section consists of 50 feet of grey limestone, calcilutite, dolomite with interbedded marl and some thin (6 inches) lenses of white chert. The beds of marl and dolomite are 2 - 5 feet thick. The formation was disconformable on the Kelly Creek Formation and conformable with the overlying Nora Formation. The beds have low dips towards the Toko Syncline.

2. **Nora Formation**

   The type section for this formation is also in Map 4. The section is approximately 300 feet thick and consists of brown to dark brown dolomite and coquinite near the base, followed by grey and purple siltstone and fine sandstone, and green and brown glauconitic sandstone.

   In the Toko Syncline the Formation is conformable with overlying and underlying beds while in the Tarlton Range near Beantree Bore it disconformably overlies the Kelly Creek Formation and at The Pinnacles (near Tarlton Downs homestead) there is a disconformity with the overlying Carlo Sandstone.

3. **Carlo Sandstone**

   The Carlo Sandstone forms the top 20 feet of the Toko Range scarp (Map 4) and also forms the rim of the scarp in the Tarlton Range where it is approximately 50 feet thick with the upper beds eroded away.

   The lithology is a medium bedded, fine to medium-grained quartz sandstone, with ripple marks and flute casts; in the Tarlton Range (Map 3) clay pellets can be found in the lower part of the unit.
(4) **Mithaka Formation**

The Mithaka Formation is approximately 400 feet thick in the Toko Syncline and 50 feet in the Tarlton Range where it only outcrops over a small area on top of the range just north of Map 3.

The main lithology is brown and grey gypsiferous siltstone and shale, calcareous siltstone and some white glauconitic quartz sandstone.

The formation is conformable with the underlying Carlo Sandstone.

(h) **TARLTON FORMATION (Triassic)**

Large areas between the Tarlton Range and the Toko Syncline are covered by outcropping Tarlton Formation. This formation is flat lying and frequently forms the caps on mesas and ridges. It consists mainly of quartz pebble conglomerate, brown/red sandstone and grey siltstone. The formation is often strongly iron stained and altered to greybilly.

The Tarlton Formation is readily distinguished from the Kelly Creek Formation and Tomahawk Beds which it frequently overlies despite the similar lithologies.
3. ENVIRONMENTS OF DEPOSITION

The Marqua Beds are characterised by their thin bedding, fine grain sizes and cyclical nature of deposition. Terrigenous material is nearly absent while pyrite nodules suggest a quiet reducing environment, perhaps near shore.

The Arrinhrunga Formation represents a complete change in conditions with thick bedded arenaceous units being deposited together with oolitic bank deposits, calcarenites and siltstones. There was some increase in the supply of terrigenous material towards the top. Throughout the Arrinhrunga Formation there is a cyclical pattern to the deposits. The Arrinhrunga Formation is overlain disconformably by both the Tomahawk Beds and the Ninmaroo Formation.

The Tomahawk Beds represent an increase in the supply of terrigenous detritus, although fine grained. The seas probably transgressed over basement highs during this time and here was the locus of sedimentation for the bank deposits now found in Map 3. Both in the major east-west anticline and the smaller anticline south of Mulga Bore there are rapid lateral changes in facies. Near New Bore there are fore-reef type breccias on the northern limb. South of Mulga Bore the facies changes laterally from a carbonate sequence in the west to a siltstone, calcarenite sequence to the east and along the flanks.

The Ninmaroo Formation is dominantly carbonate deposition including banded dolomites, limestone (thick and thin bedded), calcilutites and calcarenites.
4. CONCLUSIONS

Several factors could be considered to provide a favourable environment for the deposition of stratiform lead-zinc deposits in the area studied. They include:

(1) The known occurrence of galena in vughs within a dolomite bed in B.M.R. Gr. 12. This cored drill hole is with A.P. 2875 and the galena at the surface in both the Arrinthurunga Formation and Tomahawk Bed in areas to the northwest (Box Hole Bore and Ooratippra respectively).

(2) Dolomites and limestones of Ordovician - Cambrian age are considered favourable lithologies for this type of mineralisation. Both these lithologies are common within the authorities to prospect.

(3) Stratiform ore bodies are frequently related to positive structures including basement "knobs", calcareous sand banks, algal reefs and structural anticlines. All these features occur within the authorities to prospect.

(4) Solution activity, brecciation, slump structures, thinning of bed and disconformities are present in the area examined and are considered favourable features.

(5) Porosity is high in some horizons of the Tomahawk Beds, Arrinthurunga Formation and Ninmaroo Formation. Vughs up to 1 inch in diameter are common together with fracturing and jointing. High permeability would allow metal bearing brines to move into the formations.

(6) Traces of hydrocarbons, proximity to basin margin, passive structural region and absence of igneous rocks are other features of the areas which are frequently associated with stratiform type lead-zinc deposits.

These factors make the Arrinthurunga Formation, Tomahawk Beds and Ninmaroo Formation the most favourable prospects for stratiform lead-zinc deposits.

Subsurface information indicates increased porosity and permeability below the surface layer. A lot of carbonate is being rapidly reprecipitated at the surface (due to the high evaporation rate) and this is concealing porosity, particularly in intraformational breccias, fore-reef breccias and slump structures. Gr. 12 and B.M.R. 12 both showed highly permeable horizons. Furthermore in the area covered by Maps 2 and 3
six water bores have been sunk and aquifers have been encountered in the 200-600 ft. range in all bores with the quality of the water being variable.

It is recommended that future work be concentrated on four areas:

(1) The Ninmaroo Formation between Burnt Well and Craigie Fault (Map 4). Here slumping has occurred in the dolomites and calcarenites, together with jointing and good porosity.

(2) The Arrinthurnga Formation immediately north of Christmas Creek Dam. All four units of the Arrinthurnga Formation outcrop here and unconformably overlie the Marqua Beds. Some thinning and pinching out of units occurs. Porosity is high in some horizons particularly in dolomites in unit 1.

(3) The Arrinthurnga Formation and Tomahawk Beds in the subsurface near Beantree Bore (Map 3) where they probably pinch out against a basement high.

(4) South of Mulga Bore where the present anticline and slumping represents a carbonate bank type of environment containing several porous horizons. This area extends south to Limestone Creek (Map 5).

All four areas could be further examined by geochemical methods. Limestone Creek and the creek near New Bore (Map 3) would cover areas 3 and 4, while Marqua Creek, Christmas Creek and North Gaphole Creek would cover areas 1 and 2.

For deposits that are completely strata bound, pattern drilling provides the most information as to environments as well as actual orebodies.
DIAGRAMATIC SECTION A.B. (Map 5)