APPRAISAL OF EXPLORATION RESULTS AND PERMISSIBLE
EXPENDITURES, ANGEL GROUP, TENNANT CREEK GOLDFIELD,
NORTHERN TERRITORY, AUSTRALIA.

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Summary & Conclusions

Available information concerning the degree of success achieved by exploration expenditures for copper and gold in the Tennant Creek Goldfield indicates that £122,000 is a permissible expenditure for a complete search of the primary and secondary zones of an ore target of substantial size.

The Angel Group of leases cover one of the largest aeromagnetic anomalies in the Tennant Creek Goldfield. Two main target areas are present, namely the Crusader-Black Angel and White Devil ironstone bodies. A complete search of the primary zone is yet to be carried out in both areas.

In the White Devil area gold has been intersected in one drillhole and thus additional drilling is required to determine its continuity and extent. In the Crusader section drilling has shown that copper anomalies persist in depth, that the zone of oxidation is deep and consequently the primary zone should be tested.

Surrounding the Angel Group is an area of 48 square miles held as an Authority to Prospect. The aeromagnetic map indicates that extensions of the Explorer 5 group of anomalies may be present. This Authority to Prospect because of its geological setting is worthy of geological and geophysical investigations with follow-up drilling of ore targets as they become delineated.

Introduction

The Tennant Creek Mining Field occupies an area of some 2,500 square miles and is generally taken to be that area lying between Latitudes 19° 10'S and 19° 50'S and Longitudes 133° 45'E and 134° 38'E.

This report attempts to value the known deposits of the Field and draw conclusions as to the permissible exploration expenditures for a complete search prior to withdrawal in the Angel Group and the surrounding Authority to Prospect of 48 square miles. The permissible exploration expenditures are based on the estimated chances of success in finding an economic ore deposit in the light of known geological knowledge concerning the Goldfield.

The results of exploration and the geology of the Angel Group have been detailed in earlier reports by the writer. The geological setting of the mineralised bodies is briefly reviewed together with the known geological controls of ore deposition.

Types of Orebodies

The gold and sulphide orebodies of the Tennant Creek Goldfield are in shales, siltstones and graywackes of Lower Proterozoic Age which have undergone moderate to severe folding and shearing. The following igneous rocks are intrusive into the sedimentary rocks: granite, adamellite, quartz-feldspar porphyry, diorite, dolerite and lamprophyre bodies.
Most of the known orebodies are associated with quartz-magnetite and quartz-hematite masses colloquially termed ironstones. The ironstones range from a few inches to more than forty feet in width and up to several hundred yards in length. Most of the bodies are tabular or lenticular but some are pipelike.

The ironstones occur in fault or shear zones, as replacements of unsheared or slightly sheared 'favourable' beds or at the margins of some of the larger porphyry bodies especially along concordant contacts. Beds favourable to the replacement by ironstone bodies have been purple hematite shale. Slump structures as indicated by masses of breccia are reportedly good hosts to ore but more evidence to confirm such an ore control is needed. The ironstone bodies in the hematite shale and along the concordant porphyry contacts tend to be jasperoidal. Hematite and magnetite masses along the margins of porphyries have produced little gold.

Factors Related to Probability of Success and Permissible Exploration

Expenditure.

General: Within the Tennant Creek Field 117 mines have produced gold. Two mines (Peko and Orlando) have produced gold and copper. Another three ore deposits (Explorer 5, Explorer 3 and Ivanhoe) are potential gold and copper producers. It has been indicated that in a relatively homogeneous but fractured geological unit in any area of about 50,000 square miles there are 100 mining regions of all sizes and the pattern for each is roughly the same, namely:

1 deposit worth £A33,000,000 or more
3 or 4 deposits worth £A3,300,000 - £A33,000,000 or more
8 to 12 deposits worth £A330,000 to £A3,330,000

and a tail of small ones.

Broadly speaking the average area of the mining region in the unit area of 50,000 square miles is about 500 square miles. The Tennant Creek 1 mile sheet area is about 550 square miles and in that area have been found:

<table>
<thead>
<tr>
<th>Mine</th>
<th>Approximately Gross Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peko</td>
<td>£30,000,000</td>
</tr>
<tr>
<td>Nobels Nob</td>
<td>£11,000,000</td>
</tr>
<tr>
<td>Ivanhoe</td>
<td>£4,000,000</td>
</tr>
<tr>
<td>Eldorado</td>
<td>£1,600,000</td>
</tr>
<tr>
<td>Explorer 3</td>
<td>£1,500,000</td>
</tr>
</tbody>
</table>

For the Tennant Creek Field itself (i.e., an area of 2,500 square miles) possibly more regions could be found by continued exploration but at least one more region is expected to be present. So far only two additional mines have been proven, namely Orlando and Explorer 5 valued at approximately £3,000,000 and £23,000,000 respectively. The figures quoted are based on published ore reserves and production figures.

Exploration Expenditures: As far as exploration expenditures in the Tennant Creek field are concerned no breakdown of expenses has been published. The total exploration expenditures by individuals, companies and
government agencies can be estimated only by a close analysis of
government and company records.

The Orlando deposit is reported as being initially
tested by a diamond drilling program of 7 holes begun in September,
1957. Assuming that the average hole length was 500 feet and not
allowing for additional drilling by wedging from any of the holes then at
least £30,000 was spent on testing the primary ore zone 350 feet below
the surface.

The Ivanhoe deposit is reported as being established as
a mine by diamond drilling after preliminary geological and geophysical
work had been carried out. The minimum drilling expenditure was of
the order of £30,000. Expenditures on Explorer 5 are considered
to be in the vicinity of £100,000 or more.

It seems that Peko Mines N.L. alone has spent more
than £500,000 on exploration at Tennant Creek since 1957.

**Empirical Evaluation of Probability of Success and Permissible Exploration**

**Expenditure**

Extensive leaching has taken place throughout the Goldfield.
Diamond drilling of many of the mineralized bodies has shown that the
presence of economic deposits of secondary copper ore above 280 feet and
of primary sulphides above 380 feet is unlikely. Enriched gold ores occur
in this zone of leaching. Copper and bismuth are associated with gold and
consequently when present in anomalous quantities may be used to define
exploration targets for gold in the zone of oxidation and enrichment and
for sulphide minerals in the primary zone.

Much emphasis has been placed on the testing of ironstone
bodies especially those that have a high copper content. However although
both gold and copper have been found in and immediately adjacent to iron-
stone bodies it is now becoming apparent that both elements can be
dispersed in the country rocks peripheral to the ironstone. Orlando is a
good example and the geochemical survey of the Angel Group shows that
the copper and bismuth anomalies are zoned with respect to the magnetic
anomalies. The recognition of mineral zoning introduces a new parameter
into mineral exploration in the Tennant Creek Goldfield. Whilst no
probability factor can be allotted to it in determining the chances of success
mineral zoning must be considered as a guide to ore at depth. One result
of zoning is that a low copper content in an ironstone body does not rule
out the occurrence of ore in the surrounding rocks as magnetite and copper
may have been deposited from the ore bearing solutions at different times.

(a) **In the Zone of Oxidation and Enrichment**

Seven hundred ironstone bodies have been prospected
in the 560 square mile area around Tennant Creek (the 1-mile sheet
area). Prior to 1950 gold was found associated with 120 ironstone bodies.
Mining and exploration proved that one ore body (Noble's Nob) had a gross
value of £11,000,000 and another (Eldorado) a gross value of more than
£1,500,000. Up to the present these two mines are the only mines of real
economic significance so far as gold production in the zone of oxidation
and enrichment is concerned. The chance of finding a mine such as
Nobles Nob can possibly be rated as 1 in 120. Assuming the net return
from Nobles Nob will eventually be £7,000,000 (it was £5.45 million till September 1964) then using Calloway's formula the permissible exploration expenditure to ensure a complete search in this zone can be calculated as approximately £57,000.

(b) In the Primary Zone

In the primary zone the chances of success seem to be greater because of the presence of copper as well as gold. Ivanhoe and Peko are deposits proven to be economic. Assuming the net value of Peko is £3,000,000 then the permissible exploration expenditure is seemingly \( \frac{1 \times 3 \times 10^6}{2.5 \times 10^6} = 25,000 \).

However if the ironstone body is associated with a strong magnetic anomaly the chance of success increases considerably.

Inspection of the aeromagnetic map of the Tennant Creek 1-mile sheet shows that the most conspicuous anomalies are those of Peko, Golden Forty, Gigantic and Ivanhoe. Peko and Ivanhoe are economic deposits. Beyond the limits of the 1-mile sheet area are about twenty anomalies, the immediately obvious ones being Orlando, Explorer 5, the Angel Group, the Red Bluff Group and Explorers 6 and 7. Generally the mines associated with the hematite shale are peripheral to the aeromagnetic high plateau (i.e. above 3,000 gammas of Tennant Creek.) Production wise the deposits which have produced or are known to be capable of producing more than 10,000 ozs., of gold or the equivalent thereof in the primary zone are related to aeromagnetic anomalies. Thus the chances of an orebody being found are directly related to the size and intensity of aeromagnetic anomalies.

About 40 aeromagnetic anomalies are present in the 1-mile aeromagnetic map area so that the estimated chance of making a discovery becomes \( \frac{1}{40} \) rather than \( \frac{1}{123} \).

Thus, the permissible exploration expenditures increases to £75,000 for a complete search of the primary zone of a magnetically anomalous area.

Summing up it seems that the permissible maximum expenditure for testing the primary and secondary zones of an aeromagnetic anomaly prior to withdrawal is £122,000 (i.e. £75,000 + £57,000) depending on its size.

The Angel Group

The magnetic anomalies of the Angel Group are two of the largest on the field. Furthermore the mineralized zone is one of the most pronounced and the ironstone bodies some of the biggest. The presence of two distinct magnetic anomalies and the grouping of the ironstone bodies in two areas (i.e. the Black Angel Area and the White Devil Area) suggests that each should be treated as separate exploration targets. To ensure a complete search of the Angel Group exploration expenditures could total £200,000.

The exploration work carried out to date indicates that

1) The zone of oxidation in the Crusader section of the Black Angel Area is comparable to elsewhere in the field - a fact not previously recognised.
2) The possible presence of pockets of secondary gold in the vicinity of No. 6., workings was revealed by twelve waggon drill holes.

3) The concentrations of copper minerals being outside the 4,000 gamma contour are peripheral to the magnetic anomalies and consequently negative results of testing the central part of the magnetic anomalies alone is not conclusive evidence that copper ore is absent. The relationship of the geochemical anomalies to the 4,000 gamma contour at the Black Angel suggests that in the White Devil Area extension of the geochemical survey should be carried out particularly northwards and eastwards towards the soil-covered flat to check the possibility of mineral zoning and thus the likelihood of ore at depth.

4) At least two of the surface geochemical copper anomalies persist in depth. Investigation of the primary zone by diamond drilling could possibly be worthwhile, more particularly in the area of anomaly 3b.

5) The work done has confirmed that no assessment can be made concerning the value of the Angel Group with respect to secondary gold ore. Additional pockets of ore are quite possible but close prospecting is not warranted at this stage.

6) In the White Devil section drill hole BA3 must be regarded as a discovery hole. Gold bearing material assaying 17.7 dwt., over 21 inches (inclined) and 6.5 dwt., over 60 inches (inclined) was found about 320 feet vertically below the surface.

In view of the above results and the conclusions herein regarding permissible exploration expenditures testing of the primary zone is recommended embracing the following:

1. Test the Crusader geochemical anomalies for copper and gold ore between 800 and 1,000 feet below ground level by diamond drilling.

2. Complete the search for ore intersected in BA3 by drilling to test the lateral and downward extensions of the ore zone.

3. Test the primary zone of mineralization beneath the Black Angel workings between 800 and 1,000 feet below ground level.

4. Test geochemical anomalies 1 and 3 (b) in the primary zone by drilling at least one hole into each anomaly.

5. Extend the geochemical survey of the White Devil Area northwards and eastwards.

Authority to Prospect of 48 square miles.

Ground investigations and analyses of the aeromagnetic intensity map show:

1. The Angel Group of magnetic anomalies are localised on the eastern side of a northeasterly shear zone.

2. The anomalies are on the north side of a magnetic ridge which trends southeastwards from Explorer 5. In the northwestern corner of the Authority to Prospect is the southeastern extension of the Explorer 5 group of anomalies. Such extensions should be tested by drilling.
One ironstone body has been located on this ridge south of the Angel Group.

3. The area is traversed by northeasterly fractures which seem to exert an important control on ore localization throughout the Tennant Creek Field.

4. Much of the Authority to Prospect is covered by soil and consequently ground geophysical and geochemical surveys will be necessary to locate target areas for diamond drilling.

5. The area in view of its geological setting should be explored. The cost of testing to maximise the profit ratio is expected to be of the order of £250,000.

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