FINAL REPORT

PROSPECTING AUTHORITY 1945,

TANAMI DISTRICT
NORTHERN TERRITORY

by

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Anaconda Australia Inc.
34 Hunter Street
Sydney. N.S.W.
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SUMMARY

Prospecting Authority No. 1945 which covered an area of 1,034 square miles in the Tanami district of the Northern Territory was granted to Anaconda Australia Inc. on March 27, 1968. This report sets out details of work undertaken by Anaconda in the concession.

The Prospecting Authority was geologically mapped at a scale of one inch to the mile but most emphasis was placed on exploration of the Lower Proterozoic rocks in the Black Hills district where Enterprise Exploration Pty Ltd had previously investigated a long zone of gossanous ridges.

In the Black Hills district Anaconda carried out a program of geological mapping, ground magnetometer surveys, auger drilling and soil and outcrop sampling. An area of about eight square miles was mapped in reconnaissance detail at a scale of 1 inch to 400 feet; 77,000 feet of magnetometer traverses were run, and a total of 256 Gemco auger holes with an aggregate footage of 4861 feet (average depth 19 feet) were drilled. A total of 294 soil samples and 95 rock samples were analysed.

The investigations failed to reveal evidence of significant mineralization in the area and despite the reconnaissance nature of the survey it down graded some of the more readily apparent possibilities to a point where further expenditure could not be justified and accordingly the area was relinquished.
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INTRODUCTION

Location and Access

Prospecting Authority No. 1945 lies in the Tanami district in the central-western part of the Northern Territory. The Authority covers an area of 1034 square miles and is bounded by latitudes 19°35'S and 20°00'S, and longitudes 129°35'E and 130°06'E except where impinged upon by two areas held by Peko Wallsend Investments Ltd (Plate 1).

The area is 400 road miles north-west of Alice Springs and about 50 miles from the Western Australia border. The nearest settlement of any kind is 140 road miles distant and the nearest town (Halls Creek in Western Australia) is 260 miles away. The area is accessible by dirt road from Alice Springs via Yeundumu; from Alice Springs to Yeundumu (180 miles) the road is well maintained, but from Yeundumu to Tanami (220 miles) it degenerates into a rough track and is impassable after rain. Two tracks link Tanami with Halls Creek 250 miles to the north-west - the southern track leads westwards from Tanami to connect with the Balgo-Billiluna road and the northern track leads north-west through Gordon Downs Homestead. A rarely-used track leads northwards from Tanami for 140 miles to Hookers Creek Settlement.

Tenure

The Prospecting Authority was granted to Anaconda Australia Inc. by the Northern Territory Administration for a period of 12 months commencing March 27, 1968.

Topography and Climate

The Prospecting Authority lies in an uninhabited semi-desert region with an average annual rainfall of about 10 inches. Most of the rain falls between November and March. The daily average maximum temperatures range from 75°F in July to 100°F in January while the daily average minimum temperatures range from 45°F in July to 75°F in January.
The area is mostly flat, sand-covered and featureless, broken only by low sandstone ridges, rare laterite scarp and, in the Black Hills district, by gossanous ridges. The area lies between 1500 and 1700 feet above sea level and local relief rarely exceeds 100 feet. It sustains a fairly dense growth of spinifex and scattered clumps of shrubs, but trees are not common and for the most part the country is open grassland.

There is no permanent surface water in the Prospecting Authority, although Camel Waterholes and Goomarie Spring provide small, near-permanent supplies. A government bore at Tanami was used as a source of water during our field activities.

**Previous Investigations**

The Tanami district was not explored until 1900 when Allan A. Davidson, working on behalf of the Central Australian Exploration Syndicate, made extensive journeys (by camel) between the Overland Telegraph line and the West Australian border (Davidson, 1905). Davidson discovered traces of gold at Tanami and at The Granites (65 miles to the south-east) and these remain the only localities in the entire district where mining has taken place. At Tanami prospecting parties located further gold occurrences and by 1909 some 60 men were on the field.

H.Y.L. Brown, the government geologist, visited the field in 1909 (Brown, 1909) and reported on the geology of the mines and the surrounding district. C.E. Gee, a Mining Warden, visited Tanami in late 1909, and reported on the mining activities (Gee, 1911). Mining continued intermittently and Jensen (1915) and Hossfeld (1940) wrote reports on the field. Hossfeld estimated that the total production up until 1927 was about 2,500 oz. of gold. To 1960 the Granites field had yielded about 13,500 ounces of gold.

Apart from the work of Davidson in 1900 the first systematic regional exploration was done by K.R. Phillips on behalf of Enterprise Exploration Pty. Ltd between
1959 and 1961 (Phillips 1962). His geological reconnaissance of large parts of the Tanami and The Granites 1:250,000 sheet areas was followed by an assessment of areas where gossanous bodies had been located. Gossan sampling, soil sampling and ground magnetometer surveys were carried out over selected areas, including the Black Hills district where most of Anaconda's activity has been centred. In 1962 Enterprise Exploration Pty. Ltd. tested a gossanous body in the southern part of the Black Hills with a diamond drill hole and encountered 166 feet core length of black carbonaceous shale containing 10-15% pyrite and 0.35% Zn, corresponding with the gossan. Further down the hole 90 feet of 'talc phyllite' averaging 0.1% Cu was intersected. The hole bottomed in mineralized rock.

During 1961 the Bureau of Mineral Resources (Mulder, 1961) conducted a low-level airborne radiometric survey of the Tanami area, including the southern and central parts of the present Prospecting Authority. Line spacing varied from 1/2 to 1/4 of a mile. No radiometric anomalies were located in the parts of PA 1945 covered by the survey. In 1962 the Bureau conducted an airborne magnetic and radiometric survey of the Tanami (and The Granites) 1:250,000 sheet areas (Spence, 1964) using 1 mile line spacings. The aeromagnetic survey outlined a number of moderate to strong anomalies.

**Investigations by Anaconda Australia Inc.**

Before field work began a photo-geological map of the Prospecting Authority was prepared. Field investigations began on June 4, and were completed on August 21.

The program involved regional and detailed geological mapping, ground magnetometer surveys and soil, outcrop and augerhole sampling.

**Geological Mapping:** The Prospecting Authority was geologically mapped at photo-scale (approximately 1 inch to 3875 feet) and an area of about 8 square miles in the South Black Hills was mapped in reconnaissance detail at a scale of 1 inch to 400 feet.
Ground Magnetometer Surveys: Ground magnetometer surveys were conducted in the South Black Hills area where 71,000 feet of grid were traversed and in the North Black Hills where a single 6,000 foot traverse was run. Station intervals of 50 feet were used throughout.

Geochemical Sampling: A total of 256 Gemco auger holes with an aggregate footage of 4861 feet (average depth of 19 feet) were drilled. Of these 242 were in the South Black Hills, 9 were in the North Black Hills and 5 were elsewhere in the Prospecting Authority. Samples from the bottom of all holes were submitted for AAS determinations of the copper, lead, zinc and nickel contents. Soil and outcrop sampling were confined mainly to the South Black Hills area; 294 soil samples and 95 rock samples were collected.
REGIONAL GEOLOGY

Rocks of Precambrian age underly most of the Prospecting Authority but over wide areas they are covered by thin surficial deposits. Along the eastern margin of the Authority a tract of 'black' soil probably overlies Cambrian carbonate rocks and small isolated outcrops of Mesozoic (?) and Tertiary sediments occur in other parts of the Authority. A summary of the regional stratigraphy is given in Table 1.

**Lower Proterozoic (?)**

The oldest rocks in the area are the low-grade metamorphic rocks, sediments and basic metavolcanics in the Black Hills district. The rocks are generally steeply-dipping and although minor structures suggest that the sequence may be isoclinally folded, there is no evidence of repetition of beds. The convergence of the gossanous zones in the southern part of the Black Hills suggests a large-scale steeply-plunging fold, but partly because of the general lack of outcrop, we have been unable to definitely establish such a fold.

On a regional scale three rock units (Plv, Plb, Plc) have been distinguished. The stratigraphic relationships between the units cannot be established and there is no evidence available to indicate the order of superposition of the units.

**Plv** consists of fine to medium-grained green-black amphibolite. The rocks are strongly cleaved but in hand specimen only very weak foliation is apparent. Rare amydales filled with quartz, chalcedony, calcite or epidote are present and suggest that the rocks are probably metabasalts. Quartz veins up to 6 inches across are common in the amphibolite, but no mineralization has been found in the veins. Epidote veins and smears are abundant and scattered calcite-epidote veins are present; malachite was found at one locality in a calcite-epidote vein.
Plb consists of a variety of fine-grained sediments and low-grade metamorphic rocks, and includes pyrite-rich shales which give rise to the strong sericite-kaolin-iron oxide outcrops of the Black Hills. The unit is discussed in more detail on another section of this report.

Plc is distinguished from Plb by its content of cherty rocks. The unit consists of closely interbedded chert, pyritic chert, ferruginous chert, cherty ironstone, siltstone and shale. In the north Black Hills these rocks appear to interfinger with the rocks of Plb, and a similar relationship could apply south-east of the south Black Hills.

Pg A single group of exposures of biotite-muscovite granite occurs east of the Black Hills but a distinctive air-photo pattern indicates that granitic rocks underly a thin sand-blanket over most of the eastern part of the Prospecting Authority. The exposed rocks range from massive, medium, even-grained granites to types phryric in quartz and feldspar. Major joints show up well on the air photos - the two most prominent trends are 045° and 300°. Quartz dykes trending at 300° cut the granite. No contact between the granite and adjacent rocks are exposed but it may be assumed with some confidence that the granite intrudes the Lower Proterozoic (?) sequence and that it pre-dates deposition of the middle Proterozoic succession.

**Middle Proterozoic (Carpentarian)**

The Lower Proterozoic (?)rocks are unconformably overlain by a sequence of rudites, arenites and lutites with many of the features of Middle Proterozoic (Carpentarian) successions elsewhere in northern Australia. A single isolated outcrop of acid volcanics 1 mile south-west of Mt. Twigg is located in a geographic position such as to suggest that it lies at the base of the succession. Acid volcanics are typically present at the base of the Carpentarian sequence in the northern parts of the Northern Territory.

*Not positively identified.*
and Western Australia and it is suspected that the volcanics at Mt. Twigg may have been extruded during this widespread episode of acidic volcanic activity.

The Carpentarian rocks are folded into broad, open structures with dips on the limbs of between 10° and 50°. The fold axes generally trend north-north-east.

Pca consists of porphyritic rhyolite containing scattered phenocrysts of quartz and pale green feldspar. Only one small outcrop (1 mile south-east of Mt. Twigg) is known. Weak flow (?) banding is present locally and dips measured on this planar feature suggest that the unit may be about 300 feet thick. At Mt. Twigg the unit is absent and conglomerates of Pcb rest with pronounced angular unconformity on the Lower Proterozoic rocks.

Pcb West and south-west of Mt. Twigg several isolated outcrops of massive coarse-grained pebbly arkose, arkosic conglomerate, feldspatic sandstone and quartz sandstone are present. The outcrops are separated by sandy plains and most of the succession is obscured. The conglomerates are mostly cobble conglomerates with clasts of quartzite, vein quartz and chert. Most of the rocks are cross-bedded.

Further outcrops of the unit are thought to be present in the Black Hills Homestead district where medium-grained quartz sandstone and glauconitic sandstone are associated with maroon-red siltstones and quartzose cobble conglomerates. A massive maroon-red siltstone similar to the siltstones outcropping in the Black Hills Homestead district was penetrated in a well one quarter of a mile east of Camel Waterhole.

Pc is thought to lie conformably on Pcb. The unit is at least 3,000 feet thick (no top is exposed) and consists of quartzose pebble and cobble conglomerates, quartz sandstone and feldspatic sandstone. Lateral lithological variation within the unit is strong - e.g., 8 miles north-north-east of Tanami
and west of the Hookers Creek track conglomerate is the dominant lithology while in the Tanami Range medium and coarse-grained quartz sandstones are completely dominant.

Large scale cross-bedding is common in the conglomerates and ripple-marks are ubiquitous in the arenites. In contrast to the conglomerates of unit Pc they those in Pc contain only rare chert clasts - the clasts are almost exclusively quartzite and vein quartz.

**Mesozoic (?)**

About 10 miles east of Tanami outcrops of horizontal massive yellow-orange claystone occur at the foot of laterite scarps. The claystone contains cylindrical cavities of possible organic origin (worm burrows?) and is tentatively assigned to the Mesozoic because of the lithological similarity to Mesozoic beds elsewhere in the Northern Territory. It is possible however that the bed may only be part of the laterite profile. The claystone is about 30 feet thick.

**Cainozoic**

**Tl.** Scattered outcrops of limestone, probably of lacustrine origin, occur in the western part of the Authority. In places the limestone is partly or completely replaced by chalcedony. Similar deposits are common throughout the Northern Territory.

**Czl.** Laterite is widely distributed in the Prospecting Authority - before the present erosion cycle is probably formed a more or less continuous blanket over most of the area. Complete profiles are exposed at several localities; the pisolithic, nodular and mottled zones are all well developed. In places the pisolithic and nodular material has a high iron content, notably in the central Black Hills where a small ironstone body carrying 59.0% Fe and 4.6% $\text{SiO}_2$ is developed (Phillips, 1962).
“Black” soil is developed on some of the calcium and magnesium-rich Lower Proterozoic rocks, particularly the amphibolite of Plv, and similar soil covers an area along the eastern margin of the Authority where it is thought to overly Cambrian carbonate rocks.

This subdivision includes unconsolidated residual sand, aeolian sand and soil.

The most extensive alluvial deposits in the area are in claypans and other drainage depressions. The sediments are mostly clay, silt and fine-grained sand. Alluvial deposits along the water-coarses have been largely obscured by aeolian sand.
GEOL0GY AND MINERALIZATION IN THE BLACK HILLS DISTRICT

Enterprise Exploration (Phillips, 1961) investigated the gossanous bodies in the Black Hills district between 1959 and 1962 by means of mapping, gossan sampling, soil sampling and ground magnetometer surveys. They tested one of the gossans in the southern part of the Black Hills by diamond drilling. The drill hole penetrated 166 feet core length of black carbonaceous shale containing 10-15% pyrite and 0.35% Zn; further down the hole 90 feet of 'talc phyllite' containing 0.1% Cu. (as chalcopyrite) was intersected.

The drilling established the presence of base metal mineralization in the district.

Anaconda Australia Inc. began further investigations in the district with three objectives:

(i) to investigate any possibilities of extensions and an increase in grade of the copper mineralization encountered in DDH 1.

(ii) to investigate the full length of the Black Hills gossanous zone, with emphasis on areas adjacent to the zone for indications of copper or other mineralization and

(iii) to determine the lithology responsible for a north-west-trending linear magnetic ridge shown on Bureau of Mineral Resources aero-magnetic maps to lie parallel to and within a few thousand feet north-east of the gossanous zone.

Because of the general paucity of outcrop, auger drilling was used extensively both as a means of obtaining geochemical samples and to gather lithologic and stratigraphic data. The surface mapping carried out has been of a reconnaissance nature, designed only to supplement mapping previously conducted by Enterprise Exploration. A geological map of the southern part of the Black Hills incorporating surface and subsurface information is given in Plate 2.
Stratigraphy

Details of the stratigraphy of the Black Hills district (mainly deduced from the southern Black Hills) are set out in Table 2. The summary is based on surface and subsurface data.

The succession in the Black Hills area can be divided into six units (A to E and Plv) working arbitrarily from south-west to north-east (the facing is not known). The sequence is intruded by a granite (Pg) and by a variety of siliceous dykes (gh), as well as thin quartz feldspar porphyry dykes too small to be shown at the scale of mapping.

Structure

It is not possible to gain a full picture of the structure from the outcrops available in the Black Hills district. The main outcrops are mostly of gossanous sericite-kaolin-iron oxide rocks in which relic stratification is only rarely preserved. Where stratification is present the dips are generally either near-vertical or else affected by sedimentary slump structures, micro-folding and soil creep.

On a broad scale the Black Hills gossan zone appears to form part of a steeply-dipping conformable sequence of low-grade regionally metamorphosed sediments and volcanics. The strike is north-west in the south and swings to the north in the northern part of the area. In the extreme south there is a convergence of strike suggesting a large scale fold but auger drilling failed to find the duplication of lithologies expected and it must be assumed either that no fold is present or that facies changes occur across the fold. Some credence must be given to the latter possibility because in the north Black Hills a facies change, similar to that suspected in the south, can be inferred.
Magnetometer Surveys

An airborne magnetometer survey of the Tanami district, including the Black Hills, was conducted by the Bureau of Mineral Resources in 1962 (Spence, 1962). The average flight line spacing was 1 mile and the flying height 500 feet. The results of the survey have been published in contoured form at a scale of 1 inch = 2 miles.

The airborne surveys delineated a pronounced positive magnetic feature lying parallel to and about ½ mile to the north-east of the Black Hill gossan zone.

Ground magnetometer traverses were used during the current survey to accurately position the anomalous zone so that it could be probed by auger drilling. A McPhar M700 magnetometer was employed. In the South Black Hills 71,000 feet of line were surveyed (Plate 3) and in the North Black Hills 6000 feet of line (Plate 5) were surveyed. All profiles are based on readings at 50 feet intervals and all readings are relative to an arbitrary 0 datum at 50,000X, 50,000Y, South Black Hills. The maximum diurnal variation encountered during the survey was 15. This is of the same general order as the order of accuracy of the instrument and accordingly no drift corrections have been applied.

The positive magnetic ridge north-east of the gossan zone detected in the B.M.R. airborne survey was delineated on the ground and probed by auger drilling along widely spaced lines. The drilling showed that the magnetic ridge is due to the presence of disseminated magnetite in the chlorite-sericite schists and phyllites of unit E.

A sharp magnetic peak on line 48600Y was found to coincide with a marked increase in the magnetite content of the underlying amphibolite.
Mineralization

Numerous massive to weakly-stratified-sericite-kaolin-iron oxide gossans are exposed over a strike length of 3 miles in the south Black Hills. The zone is obscured for 3 miles by laterite in the central Black Hills but gossanous exposures reappear over a strike length of 1 mile in the north Black Hills. No economic minerals have been observed in the gossanous outcrops, in fact the only direct surface indication of mineralization in the whole district are very rare malachite smears in the amphibolites to the north-east of the gossanous zone. Details of the mineralization and geochemistry of the various lithological units in the Black Hills district are summarized in Table 2.

Gossan Sampling: Enterprise Exploration Ltd's. activities in the Black Hills area were aimed principally at determining if the numerous sericite-kaolin-iron oxide gossans making up the Black Hills were associated with economic mineralization. Numerous gossan samples were assayed but the results were not encouraging - zinc values of between 0.05% and 0.4% (mostly between 0.1% and 0.2%) were obtained, but only trace amounts of copper and gold were detected. No part of the strike length of the gossanous zone yielded significantly higher values than the other parts and the drilling target was selected primarily on the basis of the surface dimensions of the gossan.

The drilling showed that the gossans (or at least some of them) are developed on black carbonaceous pyritic shale. In DDH 1 the shale contains from 10 to 15% pyrite and assays of 0.35% Zn over a true width of about 140 feet. Trace amounts of copper and gold and up to 0.05 ounces of silver per ton are present in some sections.

Random chip samples taken by Enterprise Exploration from the gossan subjected to drilling gave assays of 17.6% Fe, trace Cu, 0.05% Zn and trace Au.
Semi-continuous chip samples taken above the DDH1 section (i.e. on line 53,832Y) during the present survey (see Plate 10) gave results of the following order:

Cu 20 - 100 p.p.m. with a maximum of 160 p.p.m.
Pb 40 - 220 p.p.m. with a maximum of 8,000 p.p.m.
Zn 10 - 80 p.p.m. with a maximum of 110 p.p.m.
Ni 40 - 160 p.p.m. with a maximum of 240 p.p.m.
Ag all less than 2 p.p.m.

The results obtained on semi-continuous chip samples from gossans further to the south-east on lines 52200Y (Plate 10), and 50400Y (Plate 6) are summarized below:

<table>
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<tr>
<th>Line</th>
<th>Unit A gossan</th>
<th>Unit B gossan</th>
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<tr>
<td>52200Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>2-15 ppm</td>
<td>2-10 ppm</td>
</tr>
<tr>
<td>Pb</td>
<td>20 ppm</td>
<td>20-50 ppm</td>
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<tr>
<td>Zn</td>
<td>5-15 ppm</td>
<td>5-20 ppm</td>
</tr>
<tr>
<td>Ni</td>
<td>5-10 ppm</td>
<td>5-20 ppm</td>
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<tr>
<td>50400Y</td>
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<tr>
<td>Cu</td>
<td>2-25 ppm</td>
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<td>Pb</td>
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<td>20-35 ppm</td>
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<tr>
<td>Zn</td>
<td>5 ppm</td>
<td>5-10 ppm</td>
</tr>
<tr>
<td>Ni</td>
<td>5-10 ppm</td>
<td>5-10 ppm</td>
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Zinc values are considerably below the general order of those obtained by Enterprise Exploration, possibly because of different sampling methods.

The generally low order of the Cu, Pb and Zn values obtained in the gossans both by Enterprise Exploration and in the present survey, coupled with the results obtained in DOH 1, indicate that there is little prospect of economic sulfide bodies occurring in the main gossan zone.
Soil Sampling: Enterprise Exploration carried out extensive soil sample traverses in both the northern and southern Black Hills. Several high copper values (up to 1500 ppm) were obtained in soil samples a few hundred feet north-east of the gossan zone and it was hoped that these values may have been reflections of the zone of copper mineralization intersected in DDH 1.

In an attempt to confirm Enterprise Exploration Ltd's results a line where several higher Cu values had been reported was selected for sampling. The line chosen, 52,200Y, was sampled at 25 foot intervals between 50,000X and 51,000X; the highest copper value obtained was 15 ppm, the highest lead value 40 ppm, the highest zinc 25 ppm and the highest nickel 20 ppm (Plate 7 and 8). A further line, Line 50,400Y, was sampled at 25 foot intervals between 50,000X and 51,000X - the highest copper value obtained was 15 ppm, the highest lead 40 ppm, the highest zinc 15 ppm and the highest nickel was 5 ppm. Line 50,600Y, sampled at 100 foot intervals between 50,000X and 51,000X, gave similarly low results - highest copper 15 ppm, highest lead 25 ppm, highest zinc 10 ppm and highest nickel 5 ppm.

Thus we were unable to substantiate Enterprise Explorations Ltd's results in this area and their results elsewhere must be regarded as being suspect.

Line 53832Y was sampled at 50 foot intervals between 50,000X and 60,000X. Profiles of copper and nickel values are shown on Plate 4. Lead values were generally 20 ppm or less with a maximum of 45 ppm; zinc ranged from 5 to 30 ppm and silver values were all less than 2 ppm. Nickel values are generally between 40 and 80 ppm; only at one locality (immediately east of the gossan zone) where a value of 140 ppm was obtained, do values exceed 100 ppm. Copper values generally range between 10 and 40 ppm; the highest value obtained was 60 ppm.

Low copper and nickel values prevail over the zone adjacent to and north-east of the gossan zone while higher values occur over the chlorite-sericite schists of unit E.
Auger Sampling: Because of the extensive soil and sand cover in the Black Hills district a Gemco auger drill was used from the outset of our investigation to probe zones of potential economic interest. Fortunately in most places surrounding the Black Hills the cover is little more than four feet thick and in most holes leached and weathered rock fragments were readily obtained.

In general, drilling was continued to depths where either

(i) progress became slow or
(ii) sufficient rock chips had been recovered; samples were generally collected only from the last few feet of hole. In holes less than 4 feet deep the full length of hole was sampled; in holes between 4 and 10 feet deep the top of the sample interval was 4 feet depth; in holes greater than 10 feet deep the top of the sample interval varies from 10 feet, 16 feet, 22 feet etc., increasing in 6 foot intervals. Deeper holes were drilled in unit C (the copper-bearing beds) and a number of these holes were sampled at 6 foot intervals for their entire depth.

Initially all samples were sieved to ~80 mesh without crushing, but because of the presence of fine hematite and magnetite grains in many of the rocks it was decided that crushing was essential to obtain homogenous samples. Plate 9 compares the copper values obtained with crushed and uncrushed bottom-of-hole auger samples. Most crushed samples give higher results with the notable exception of holes 1 to 13, mostly in unit C above the DDH1 section. Holes 68 to 76, also in unit C, but 3632 feet to the south-east, give the normal pattern. The reason for this disparity is not known.

The deeper holes drilled in unit C showed that in this unit there are no sharp variations in Cu, Pb, Zn or Ni values with increasing depth. In general, the highest values are seldom more than twice the lowest.
The results of the auger drilling program are shown on Plates 4 and 5. Paradoxically the zone containing known copper mineralization (unit C) gives markedly lower geochemical values than the patently barren rocks further to the north-east. This can probably be attributed to the close proximity of the gossan zone - during the weathering cycle acid solutions derived from the pyrite in unit B would almost certainly have percolated outwards from the gossan zone and contributed to the leaching evident in unit C.

Study of auger chips and outcrops of unit C indicates that there is no significant increase or decrease of the iron oxide content along strike, or in the manner of its dispersal; as a corollary it would seem that there is little possibility within the area studied of a significant increase in copper grade along strike. The consistent pattern of distribution of iron oxide along the strike suggests that the mineralization is of the stratiform type.

Auger cuttings of unit D, a massive speckled maroon-pink-yellow sericite rock have features such as weak limonite smears and scattered fine hematite veinlets suggesting that the rock may be weakly mineralized. Values of up to 620 ppm Zn, 440 ppm Ni and 70 ppm Cu occur in cuttings from auger hole 77 (line 50,200Y) and in hole 11 (line 53,832Y) values of up to 130 ppm Zn, 300 ppm Ni and 220 ppm Cu were obtained. These values are higher than those from adjacent beds and tend to confirm the possibility that the unit may be weakly mineralized.

In unit E copper and nickel values are generally higher than in the adjacent units, but there is no indication in the auger cuttings (all oxidized, but texture well preserved) of the former presence of significant amounts of sulfides. The presence of carbonate minerals in the schists and phyllites may well account for the higher values present.

In unit Plv (amphibolites) copper and nickel values are generally lower than in unit E. Fresh rock chips were obtained from numerous auger holes but no indications of mineralization were found.
CONCLUSIONS

With some reservations imposed by the reconnaissance nature of our investigations, the depth of weathering, and by the methods employed it is concluded -

(i) That the copper mineralization encountered by Enterprise Exploration Pty. Ltd. in DDH 1 is of the stratiform type, but that there is no marked increase in grade along strike;

(ii) that the prominent linear magnetic ridge lying parallel to and north-east of the gossanous zone is a reflection of magnetite-bearing chlorite-sericite schists and phyllites and is not related to mineralization, and

(iii) that there are no clear lithological or geochemical indications of significant mineralization in areas adjacent to the gossanous zone.

The presence of phosphate (0.9% P₂O₅) in a single sample of black soil collected from the eastern part of the Authority, where the soil is believed to overlie Cambrian carbonate rocks, suggests that the geological environment may have been favourable to the accumulation of phosphates. The presence of granitic rocks along the margin of the Cambrian basin enhances the prospects, but because of the remote location, exploration at the present time would not appear to be warranted.
REFERENCES


<table>
<thead>
<tr>
<th>AGE</th>
<th>MAP SYMBOL</th>
<th>LITHOLOGY</th>
<th>MAXIMUM THICKNESS IN FEET</th>
<th>TOPOGRAPHIC EXPRESSION</th>
<th>STRUCTURE AND STRATIGRAPHIC RELATIONSHIPS</th>
<th>ECONOMIC GEOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUATERNARY</td>
<td>Wa</td>
<td>Alluvium - generally mixture of clay and fine sand</td>
<td>10-20</td>
<td>Plains; clay pans</td>
<td></td>
<td>1.9% P₂O₅ in single sample from eastern part of area.</td>
</tr>
<tr>
<td></td>
<td>Cza</td>
<td>Unconsolidated residual sand; aeolian sand, soil</td>
<td>20</td>
<td>Plains; gentle slopes, Rare dunes.</td>
<td></td>
<td>Approx. 1 million tons (10% Fe, 6.5% Cu, central Black Hills, larger body 17-19% Fe to south of Black Hills)</td>
</tr>
<tr>
<td></td>
<td>Czb</td>
<td>Black calcium and/ or magnesium - rich soil, Shrinkage cracks common</td>
<td>107</td>
<td>Treeless plains</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cz1</td>
<td>Plisitic, nodular and mottled laterite and ironstone; lateritic soil</td>
<td>40</td>
<td>Low rises; mesas</td>
<td>Horizontal, Relationship to T1 not known</td>
<td></td>
</tr>
<tr>
<td>TERTIARY</td>
<td>Ti</td>
<td>Limestone, chalcedonic limestone, chaledony</td>
<td>207</td>
<td>Rocky Plains</td>
<td>Horizontal, Rests unconformably on older rocks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**UNCONFORMITY**

<table>
<thead>
<tr>
<th>MESOZOIC</th>
<th>K</th>
<th>Massive yellow-orange claystone</th>
<th>30+</th>
<th>Slopes beneath laterite cap</th>
<th>Horizontal, Rests unconformably on older rocks</th>
<th>0.7% P₂O₅ in single sample from base of unit South of Black Hills</th>
</tr>
</thead>
</table>

**UNCONFORMITY**

| MIDDLE PROTERozoic (CARPENTARIAN) | Pc         | Conglomerate, quartz sandstone, feldspathic sandstone                      | 3000+                     | Strong strike ridges and plateaux | Folded into broad open structures with dips on limbs of from 10° to 50°, Probably conformable on Pcb. |                  |
|                                    | Pcb        | Arkose, arkosic conglomerate, feldspathic sandstone, quartz sandstone, glauconitic sandstone, red-maroon siltstone | 1000?                     | Isolated cuestas and low rises  | Dips range from 10° to 50°. Probably conformably overlies Pca |                  |
|                                    | Pca        | Porphyritic rhyolite                                                     | 3007                      | Low rise                      | Dips uncertain, Probably lies unconformably on older rocks |                  |

**UNCONFORMITY**

| LOWER PROTERozoic                  | Fg         | Biotite-muscovite granite                                                 | Sand-covered plains       | Probably intrudes Lower Proterozoic rocks | Barren quartz dykes present in places. |                  |
|                                    | Plc        | Chert, pyritic chert, gerruginous chert, cherty ironstone, siltstone shale | Several thousand          | Low, rounded hills and rises    | Steeply dipping numerous minor fold structures. Appears to be in conformable sequence with Plb, but possibly also intertongues with Plb | Disseminated pyrite (up to 1% in some chert beds) |

**UNCONFORMITY**

| PRECAMBRIAN                          | Plf        | Pyrrhotite, siltstone, pyritic shale, shale, chloritic - sericite schist and phyllite, tremolitic chert, greywacke | Several thousand          | Fault and line rises except where pyritic shales give rise to steep-sloped gossan ridges. | Steeply dipping numerous minor folds in conformable sequence with Plv. | Black pyrrhotite occurs, sericite, FeO-gossan in DDH10-15% pyrrhot, 0.35% Zn, Chalcopyrite phyllite in DDH1 averages 0.1% Cu over 6 oz. Magnetite abundant in chlorite-sericite schist. |
|                                    | Plv        | Fine to medium-grained, green-black amphibolite                         | Several thousand          | Low rises; extensive black soil plains | Strong cleavage developed, but only very weak foliation | Cut by numerous thin quartz veiniing, epidote, hornblende, calcite. |
### TABLE 2: SUMMARY OF GEOLOGY AND MINERALIZATION

**BLACK HILLS DISTRICT**

<table>
<thead>
<tr>
<th>Surface Expression</th>
<th>Maximum Width of Zone of Outcrop and Sub-Outcrop</th>
<th>Lithology</th>
<th>Mineralization</th>
<th>Geochemistry ppm</th>
<th>Magnetic Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>qh</td>
<td>Low rises surrounded by sand, soil, etc.</td>
<td>Vein quartz, quartz hematite, quartz hematite breccia, jasper</td>
<td>At rare localities minor pyrite casts present</td>
<td>Cu 10-220 N1 10-130 Zn 10-130</td>
<td>-</td>
</tr>
<tr>
<td>Pg</td>
<td>No outcrops in map area - covered by sandy soil</td>
<td>Sericite-quartz-feldspar-muscovite rock, sericite-kaolin rock, probably acid intrusives.</td>
<td>Rare weak iron oxide smears</td>
<td>Cu 4-140 N1 8-45 Zn 4-40</td>
<td>Weak</td>
</tr>
<tr>
<td>A</td>
<td>Undulating hills, including prominent linear gossan ridges</td>
<td>Strongly laminated and banded siltstone and shale (eg DDH1 0 - 493.7') Sericitic in part, Most outcrops are yellowish, weakly stratified sericite-kaolin-iron oxide rocks</td>
<td>Strong FeO laminae and bands, weak FeO veins and scattered pyrite casts in oxidized zone DDH1. Gossans are similar to those developed on black pyritic shale of unit B.</td>
<td>Cu 55-150 N1 10-100 Zn 5-75</td>
<td>Weak to moderate</td>
</tr>
<tr>
<td>B</td>
<td>Prominent gossanous ridge</td>
<td>Reddish, massive sericite-kaolin-FeO rocks minor leached laminated sediments. In DDH1 shown to be black, carbonaceous shale containing 10-15% pyrite.</td>
<td>0.35% Zn and 10-15% pyrite (mainly as laminae) in DDH1. Surface-numerous FeO veins, smears and cavity fillings. Rare boxworks</td>
<td>Cu 25-150 N1 15-120 Zn 15-310</td>
<td>Weak to moderate</td>
</tr>
<tr>
<td>C</td>
<td>Scree slope; rare outcrops in gullies</td>
<td>Maroon to pink phyllite. Commonly sericitic. In DDH1 (below oxidized zone) described as talc phyllite and carbonaceous schist.</td>
<td>0-2% fine (0.05mm) bright, weakly magnetic hematite specks in outcrops and in sugar cuttings. Scattered weak FeO-rich laminae, streaks, veins and smears. Ubiquitous FeO dust. No pronounced variation noted along strike. In DDH1 90 feet core length in this section assays 0.1% Cu as chalcopyrite</td>
<td>Cu 25-150 N1 15-120 Zn 5-75</td>
<td>Weak to moderate</td>
</tr>
<tr>
<td>D</td>
<td>Soil and sand covered</td>
<td>Speckled red-pink-yellow massive sericite rock.</td>
<td>Scattered ill-defined yellow smears and spots (limonite) 1% Pine, diffuse FeO dust.</td>
<td>Cu 55-150 N1 40-330 Zn 95-450</td>
<td>Weak to moderate</td>
</tr>
<tr>
<td>E</td>
<td>Black soil plain mostly devoid of trees</td>
<td>Green to grey chlorite-sericite schist and phyllite. Fine carbonate minerals commonly present and pink foliation common locally.</td>
<td>0-2% magnetite. Weak FeO smears and laminae.</td>
<td>Cu 25-150 N1 15-120 Zn 15-310</td>
<td>Weak to moderate</td>
</tr>
<tr>
<td>F</td>
<td>Red-black soil</td>
<td>Pale green chert containing scattered tremolite blades.</td>
<td>Rare pyrite grains</td>
<td>Cu 20-150 N1 20-110 Zn 20-110</td>
<td>Strong to magnetic ridge coincides with this unit</td>
</tr>
<tr>
<td>G</td>
<td>Black soil plain and low rubbly rises</td>
<td>Fire, medium and rarely coarse-grained grey-green amphibolite. Rare chalcedony - filled amygdales - rocks probably metamorphosed basic volcanics.</td>
<td>Generally 0-2% magnetite but locally up to 5%. Out by numerous thin quartz veins. Epidote veinings common. Rare malachite present in outcrop</td>
<td>Cu 25-420 N1 20-140 Zn 15-120</td>
<td>Generally weak with rare peaks due to sharp increase in magnetite content.</td>
</tr>
</tbody>
</table>
LEAD AND ZINC VALUES IN SOIL LINE 50,200Y, 50,400Y, 50,600Y

SOUTH BLACK HILLS

Map Scale: 1" = 4000 feet

Vertical Scale: 1" = 100 parts per million

- Lead
- Zinc

Sample Intervals: 100 feet

Drawn by: L.J. Stob<br>Plan No: 518

ANACona AUSTRALIA INC.
COMPARISON OF A.A.S COPPER RESULTS
ON CRUSHED AND UNCRUSHED
BOTTOM OF HOLE AUGER SAMPLES
SOUTH BLACK HILLS

Auger Hole Numbers

Drawn by: C.G. Eaton, January 6, 1969

ANA CONDA AUSTRALIA INC
PLAN NO. 811
PLANS SHOWING LOCATIONS
AND AAS Cu, Pb, Zn, and Ni VALUES
OF SEMI-CONTINUOUS CHIP SAMPLES
FROM GOSSANS ON LINES
S3832Y AND S2200Y
SOUTH BLACK MILLS

Scale 1" = 100 Feet

100

0

100 Feet

Drawn by: J. E. White, January 1989

AMACONDA AUSTRALIA INC.
PLAN No. 318