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THE JACOMYNSPAN COPPER–NICKEL OCCURRENCE, KENHARDT DISTRICT

by

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ABSTRACT

A basic to ultrabasic, intrusive, copper–nickel sulphide-bearing body was discovered during an airborne electromagnetic survey, on the farms Jacomynspan and Hartebeestpan, located in the Kenhardt District of the Northern Cape Province. The body, primarily a steeply dipping, differentiated, tremolite schist dyke together with some serpentinite, has a strike length of approximately 5 000 m. The dyke intrudes quartz–feldspar–biotite gneiss of the Namaqualand Metamorphic Complex.

Sulphide mineralization occurs predominantly in the upper portion of the dyke-like body and consists mainly of disseminated pyrrhotite, pentlandite, and chalcopyrite, averaging between 1 and 3 per cent total sulphides. Higher grade sulphide disseminations (up to 20 % total sulphides) occur in units of non-schistose hypersthenite within the tremolite schist.

The *in situ* tonnage and grade potential of the portion of the body occurring on the farm Jacomynspan has been estimated at 114 Mt to a vertical depth of 900 m, at a grade of 0,25 per cent nickel and 0,17 per cent copper.

Preliminary appraisal studies indicate that the body is not economically viable at present due to its low grade and near vertical attitude which would necessitate underground mining.

CONTENTS

I. INTRODUCTION

A. General

A basic to ultrabasic, dyke-like, intrusive, copper–nickel sulphide-bearing body occurs on the farms Jacomynspan and Hartebeestpan, approximately 15 km west of Putsonderwater, in the Kenhardt District of the Northern Cape Province (Fig. 1). The intrusion straddles both properties and has approximately an equal strike length of 2 500 m per property. This paper deals mainly with that portion of the body located on Jacomynspan which was investigated by Anglo American Prospecting Services (Proprietary) Limited.

The body, primarily a steeply dipping tremolite schist dyke with associated serpentinitic rocks, has been drilled down to a vertical depth of 900 m. Thirty-one intersections were made in 26 boreholes using wedge deflection techniques.

B. Discovery Details

The intrusive body was located in 1971 during a regional airborne electromagnetic (INPUT) and magnetic survey carried out on behalf of Anglo American Prospecting Services (Proprietary) Limited. The conductive body was detected on a tie line only, due to the unfavourable orientation of the flight lines relative to the dyke-like body. Ground follow-up in the area of the tie-line anomaly revealed small gossan pebbles spread over the area of the peak electromagnetic response. A subsequent airborne survey, using a McPhar 400 Electromagnetic system, with flight lines at right angles to the strike of the body, clearly defined the zone of conductivity which had a total strike length of some 5 000 m.

A significant magnetic anomaly, essentially coincident with the electromagnetic conductor, was also indicated. Based on the indications of the initial airborne survey and

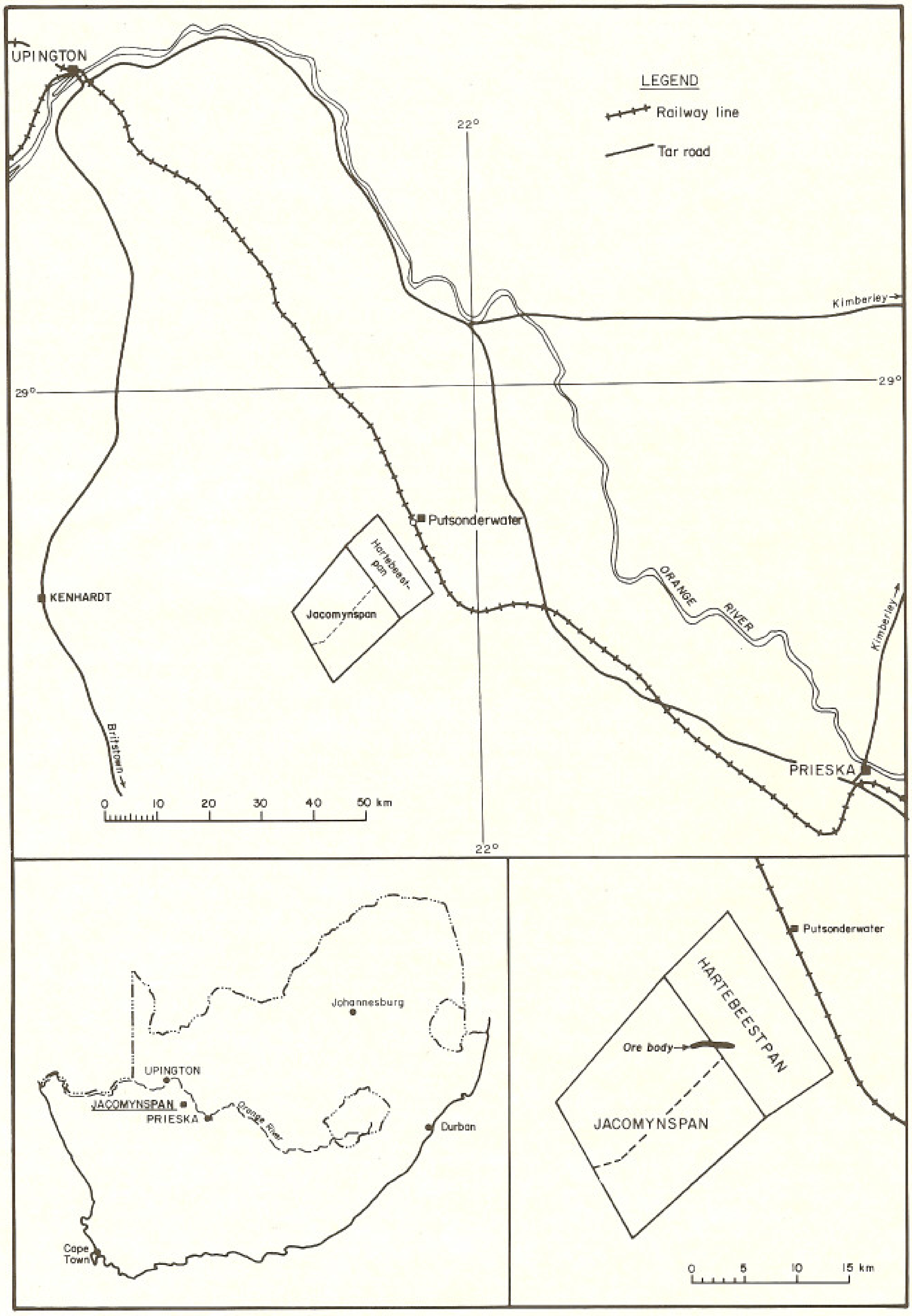

Figure I
Locality plan showing Jacomynspan in relation to existing infrastructure.

subsequent ground follow-up, a detailed exploration programme was mounted. This resulted initially in the production of a geological map of the area, based on aerial colour photography and ground mapping. This was followed by detailed geochemistry, ground geophysics, and trenching. Indications were sufficiently interesting to warrant a three-phase drilling programme.

II. EXPLORATION METHODS

A. Geochemistry

Initial ground follow-up consisted of a 6 by 4,5 km geochemical grid with 300 m line spacing and 20 m sample stations. Soil samples were screened to minus 80 mesh and assayed for copper, nickel, lead and zinc. Once the broad anomaly had been defined the grid was closed down to 50 m line spacing with 20 m sample spacing. In this case the samples were screened to minus 200 mesh in order to enhance the anomaly and improve resolution. Copper maxima were in the order of 160 ppm over a background of 30 ppm, and nickel values of 290 ppm over a background of 45 ppm. An anomalous zone, with a strike length of 2 500 m, was outlined on Jacomynspan.

The relatively thin calcrete cover in the area has a markedly depressing effect on the geochemical values, although a clear low-order anomaly was indicated. Values increase from 290 ppm Ni in soils to 4 000 ppm Ni in the schist immediately below the calcrete exposed in the trenches. No significant gossan development was found in the trenches. The tremolite schist, host rock for the sulphide mineralization, is weathered to a depth of 75 m where there is a sharp transition to fresh rock.

B. Geophysics

The electromagnetic anomaly, in conjunction with the magnetic survey, indicated a conductive body dipping approximately 60° south. The geophysical interpretation indicated disseminated mineralization or a very conductive rock type, rather than massive sulphide mineralization.

In October 1971, 1 700 Turam readings were taken on four grids situated over the potential mineralized zone. This was followed in December 1971 by an induced-polarization (IP) survey of 800 stations. The IP anomaly was rated "fair". Subsequently, considerable experimentation with various geophysical methods was undertaken. It was ultimately concluded that dipole–dipole IP was the most discriminatory method, followed by Turam and then horizontal-loop electromagnetic methods.

C. Diamond Drilling

1. Three-phase Drilling Programme

A three-phase drilling programme was mounted on the strength of the ground follow-up results.

Phase 1. This phase consisted of shallow inclined diamond drill holes drilled to intersect the body at a vertical depth of about 100 m below surface.

Phase 2. Inclined test holes to a depth of 300 to 400 m vertical depth below surface.

Phase 3. Drilling of deep, inclined boreholes to a vertical depth of 700 m aimed to intersect zones of significant mineralization down the presumed plunge.

Because of the tendency for the boreholes to lift, extreme difficulties were experienced in controlling the trajectory of the inclined boreholes which were aimed to intersect the near vertical mineralized sill at right angles.

2. Drilling Results

The first borehole drilled (PC 2–1, Figs. 2 and 3) intersected significant copper–nickel mineralization (0,29 % Ni and 0,15 % Cu over an intersection width of 69,28 m, which included 0,67 % Ni and 0,50 % Cu over an intersection width of 4,16 m). The intersection width was very close to the true width.

A deeper hole (PC 2–24, Fig. 2) which was positioned so as to intersect the body at a vertical depth of 500 m, intersected relatively high-grade mineralization (0,31 % Cu, 0,64 % Ni over an intersection width of 51,13 m which

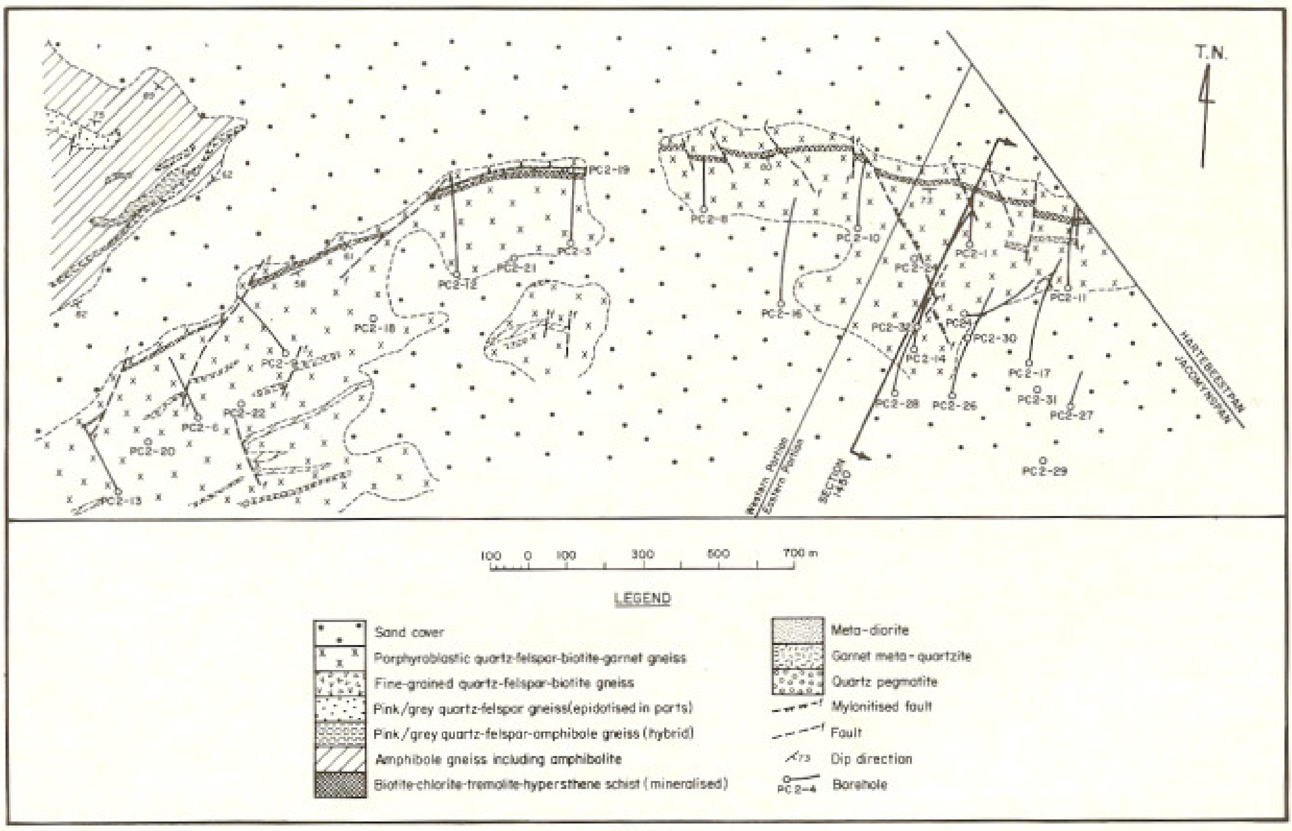

Figure 2

A geological map of Jacomynspan showing the suboutcrop of the tremolite schist intrusive body and the positions of the diamond drill holes.

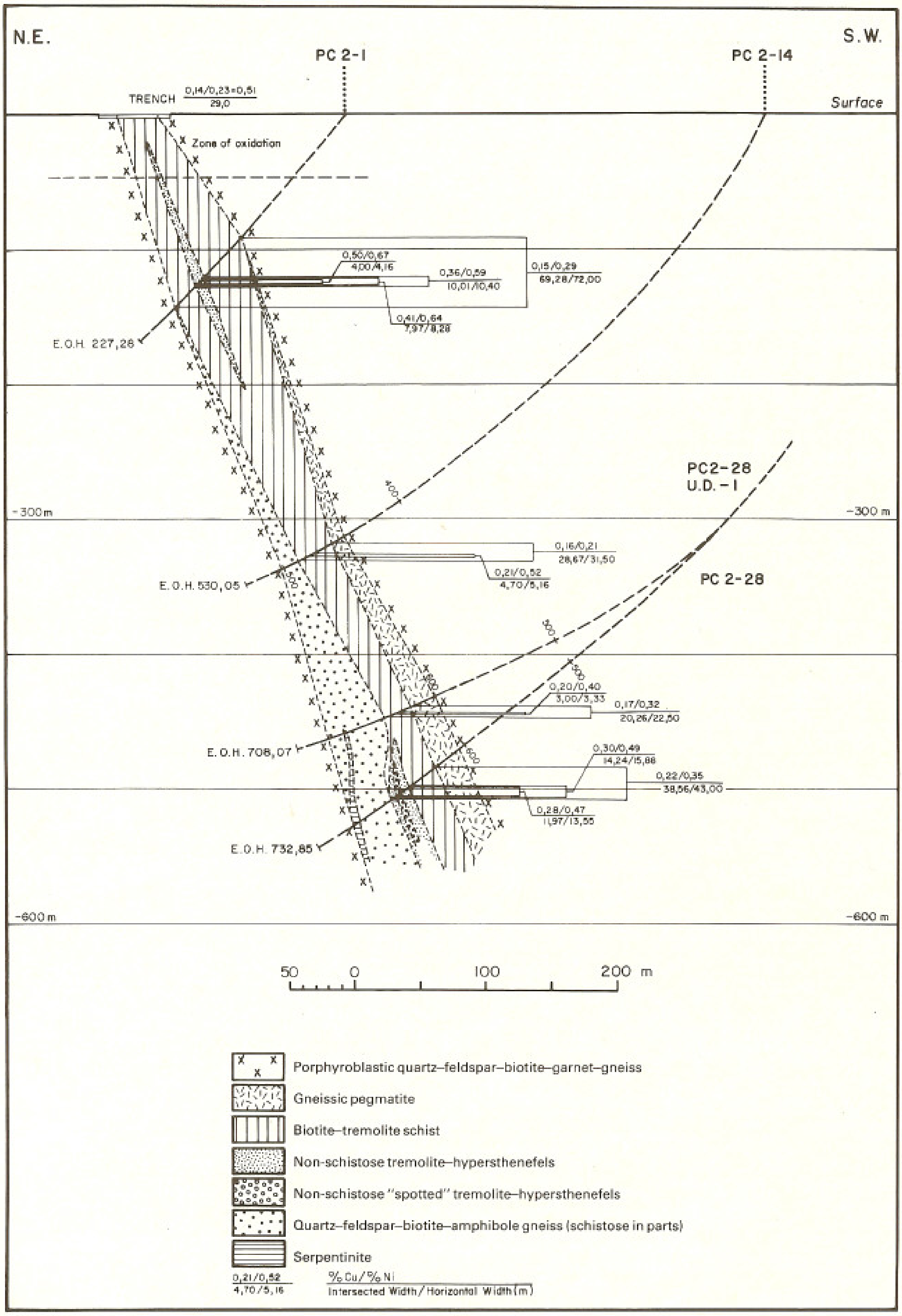

Figure 3
An idealized section on line 1450 showing the geological units in relation to the diamond drill holes.

included 0,41 % Cu and 0,86 % Ni over an intersection width of 32,28 m.

By mid-1972, six boreholes had intersected significant mineralization. Unfortunately, subsequent drill results were disappointing.

III. GEOLOGY

A. Structural Setting

On Jacomynspan the 2 500 m-long mineralized body consists essentially of a steeply dipping, dyke-like, differentiated, basic to ultrabasic body, intrusive into the country rocks of the Namaqualand Metamorphic Complex. These comprise a sequence of porphyroblastic quartz–feldspar–biotite–garnet gneisses containing minor metadiorite and amphibolite lenses. The presence of sillimanite and andalusite in the porphyroblastic gneisses infers an amphibolite facies grade of regional metamorphism.

The body extends for at least the same strike length to the east on the farm Hartebeestpan where its composition becomes more ultrabasic, i.e. serpentinitic.

The mineralized zone forms an east–west trending, curvilinear surface expression, dipping 65 to 75° towards the south (Figs. 2 and 3). Outcrops and gossan development are poor. Besides the curvilinear strike of the ore zone evidence of folding is negligible. A series of north-west and north-east-trending faults disrupt the body along its entire strike length. The orientation of the sulphide assemblages along foliation planes suggests that mineralization occurred prior to the completion of the regional metamorphism, while retrograde metamorphism has altered the original basic to ultrabasic assemblage to tremolite, actinolite, and serpentine. The Jacomynspan body thus probably represents a differentiated dyke-like intrusive emplaced along an early fault or shear zone.

B. Geology of the Ore Zone

The mineralization is found within the upper portion of a tabular, differentiated dyke-like body, intrusive into a porphyroblastic quartz–feldspar–biotite–garnet gneiss. The upper portion of the ore zone is a quartz–feldspar–biotite–tremolite schist containing poorly disseminated chalcopyrite, pyrrhotite, and pentlandite mineralization, amounting to 1 to 3 per cent total sulphides. Within this prominent schist, non-schistose hypersthene rock occurs in places and contains 10 to 20 per cent total disseminated sulphides.

The lower portion of the intrusion is represented by quartz–feldspar–biotite–amphibole gneisses, schistose in part, with poor mineralization, generally less than 1 per cent total sulphides. This zone appears to represent a hybrid zone between the overlying tremolite schist and the lower porphyroblastic country rocks.

The footwall country rocks, consisting of quartz–feldspar–biotite–garnet gneisses, are identical to the hanging wall gneisses overlying the intrusive mineralized zone. Both consist of a monotonous sequence of fine- to medium-grained gneisses together with coarse-grained pegmatitic equivalents. Poor sulphide mineralization, less than 1 per cent sulphides, consisting mainly of pyrite, occurs as disseminations and along minor joints and fractures in the gneisses.

C. Lithological Units Within the Intrusion

The ore body is composed of five distinct lithological units.

1. Serpentinite

The serpentinite is a dark grey-green, medium-grained rock of waxy appearance, composed essentially of serpentine and talc with lesser amounts of orthopyroxene, amphibole, pale green and brown mica, and olive green spinel. The rock is a highly altered pyroxene–amphibole–biotite rock, with the serpentine possibly representing an alteration product of the orthopyroxene and the talc being a product of the breakdown of the amphibole.

Serpentinite forms the lowest lithological unit of the ore zone and is of sporadic occurrence only. Where present, it ranges from 1 to 10 m in thickness and is found on the footwall contact with the gneissic country rocks, or as an intrusive into the gneisses. Minor pyrite and pyrrhotite mineralization, less than 1 per cent total sulphides, is associated with the serpentinite which probably represents narrow feeders associated with a more ultrabasic, differentiated phase of intrusion.

2. Quartz–feldspar–biotite–amphibole Gneiss

The quartz–feldspar–biotite–amphibole gneiss is a light grey rock having a weak foliation. It is composed of glomeroporphyroblasts of a very pale green amphibole and heavily sericitized oligoclase in a groundmass consisting of both these minerals and biotite. Quartz and garnet are also present in places. The crystals of amphibole and biotite, and in places plagioclase, are orientated with their longer dimensions parallel to the direction of the foliation.

This unit forms the lower, "hybrid" zone of the ore body and appears transitional between the overlying biotite–chlorite–tremolite schist and the underlying porphyroblastic gneisses. Pyrrhotite, pyrite, and chalcopyrite mineralization is poor and decreases towards the footwall to an amount of less than 1 per cent total sulphides. The thickness of the unit ranges from 10 to 30 m, generally increasing with depth. The contact with the porphyroblastic gneisses is not tectonically disrupted.

3. Biotite–tremolite Schist

The biotite–tremolite schist is a dark, grey-green, well-foliated, predominantly biotite and amphibole rock, containing from 10 to 40 per cent by volume of sericitized oligoclase feldspar. The amphibole is slightly pleochroic and appears to have properties between cummingtonite and tremolite–actinolite. Anhedral, strained quartz grains are present, but are not abundant. Thin calcite lenses of secondary origin are present in places.

The biotite–tremolite schist represents the main sulphide-bearing zone and ranges in thickness from 10 to 15 m, the width increasing with depth. Although the lower contact with the "hybrid" zone is gradational, the upper hanging wall contact is well defined, being in contact with an unmineralized quartz–pegmatite band. No tectonic disturbance is evident at this contact. Pyrrhotite, pentlandite, and chalcopyrite mineralization amounting to 1 to 3 per cent total sulphides, is disseminated throughout the schist and minor pyrite is found along joint fractures.

4. Non-schistose Biotite–tremolite–hypersthene Rock

The "spotted" tremolite–hypersthene rock is similar to the biotite–tremolite schist, except that it is characteristically "spotted" due to an opaque spinel (chromite) occurring along fractures and cleavages in the pyroxene grains. Additional olive-green spinel is also present. The remainder of the rock is composed essentially of hypersthene, tremolite, and actinolite.

Of only sporadic occurrence, the hypersthene rock, ranging in thickness from 1 to 11 m, contains significant amounts of pyrrhotite, pentlandite, and chalcopyrite (10–20 % total sulphides) and is generally found towards the base of the biotite–tremolite schist. In places the non-schistose rock is unmineralized and its presence is, therefore, not necessarily indicative of significant copper–nickel mineralization.

5. Non-schistose "Spotted" Hypersthene Rock

The "spotted" hypersthene rock is similar to the abovementioned non-schistose mineralized host, except that it is "spotted" as a result of an increase in the grain size of spinel. Again, this unit only occurs in places, but contains significant sulphide disseminations (10 to 20 % total sulphides).

6. Rocks of the Hanging Wall

Two lithological types occur in the hanging wall, a 10 to 15 m-thick gneissic pegmatite band adjacent to the hanging wall which changes gradationally to the typical, porphyroblastic quartz–feldspar–biotite–garnet gneiss. The hanging wall contact appears undisturbed, and bands of biotite–chlorite–tremolite schist and gneissic pegmatite are commonly found. Pyrite mineralization, containing less than 1 per cent total sulphides, occurs as disseminations and along joint fractures (Fig. 3).

IV. SULPHIDE MINERALOGY

Sulphide minerals are present predominantly as irregular, disseminations, averaging about 2 to 3 mm in size and reaching maximum diameter of 5 mm. Pyrrhotite is the most abundant sulphide and two phases of this mineral are present. A lighter phase, with lower reflectance, occurs around the margins of a darker phase which forms the cores of the pyrrhotite grains. Both phases are laminated and the two sets of lamellae have a flame-like appearance.

Pentlandite occurs mainly as single grains or aggregates of grains, averaging about 0,1 mm in size, at the edges of the pyrrhotite grains and along fractures in pyrrhotite. Alteration of the pentlandite produces a mixture of bravoite and violarite. Lesser amounts of pentlandite form needles and flame-like exsolution segregations within pyrrhotite. These spindles are up to 0,5 mm in length.

Chalcopyrite, mostly in association with pyrrhotite, is present in amounts approximately equal to that of pentlandite. The average size of the chalcopyrite grains is about 0,05 mm. Cubanite exsolution lamellae are present in places in the larger chalcopyrite grains.

V. ECONOMIC ASSESSMENT

A. Lithological Units

For the purpose of ore reserve calculations, the mineralized body has been subdivided into the following idealized lithological units.

Granite–gneisses (hanging wall formation)
Pegmatite marker

"Ore" Zone:
- Biotite–tremolite schist (Type A)
- Hypersthenite (Type B)
- Felsic schist, not always present (Type C)

} "Ore body" as used for ore reserve calculations

- Non-schistose gneiss, in places mineralized (Type D)
- Serpentinite (Type E)

Gneisses (footwall formation)

Sub-division of the body into "ore" types is as follows:

(i) The biotite–tremolite schist is everywhere present (Type A)

(ii) The hypersthenite (Type B) was not encountered in all intersections. This type in places has a central "core" of spotted hypersthenite with a high sulphide content (15–20 % sulphides).

(iii) The felsic schist (Type C) was not intersected in all boreholes, e.g. Type B in places passes transitionally into Type D, non-schistose felsic ore. This type forms the lower portion of the "ore zone" and grades transitionally into the footwall gneiss. It is mineralized in part, only four boreholes having intersected significant footwall mineralization, but has not been included in the ore reserve calculations.

Type E is seldom present.

B. "Ore Reserve" Areas and Blocks

1. Subdivisions Along Strike

The mineralized body has been subdivided along strike into a western and eastern area.

(a) The Western Area

This area extends 2,4 km westwards from the 1 300 section line and has only been drill tested to 150 m vertical depth by 11 boreholes spaced along strike at ± 150 m intervals (Fig. 2).

(b) The Eastern Area

The eastern area extends eastwards from the 1 300 section line to the boundary fence of Hartebeestpan (a strike extent of 532,50 m at surface) and has been drilled to a vertical depth of 900 m.

C. Total Indicated Tonnages and Grades on Jacomynspan

1. Eastern and Western Portions

Ore Type	Tonnes *in situ* × 10^6	% Cu	% Ni
Total oxide ore	6,42	0,13	0,19
Total sulphide ore	107,76	0,17	0,25
Total sulphide and oxide ore	114,18	0,17	0,25

2. Tonnage Calculations

The method used to calculate the tonnages and grades was the "Polygon of Influence" method related to a longitudinal vertical projection of the ore body intersections. A tonnage was calculated for the oxide zone between 0 to 75 m vertical depth and then for the upper zone (75–300 m vertical depth) and similarly for the intermediate and lower zones, i.e. 300 to 600 m and 600 to 900 m vertical depth, respectively. In the western area, however, the sulphide zone was only calculated to 300 m vertical depth. Relative densities used were 2,4 for the oxide zone and 2,7 for the sulphide ores.

VI. THE PORTION OF THE BODY ON HARTEBEESTPAN

The portion of the body occurring on the adjoining property, Hartebeestpan Q4.12 to the east, was simultaneously prospected by Anglovaal Limited. Prospecting work was carried out on three INPUT anomalies located during a regional airborne Barringer Input survey.

A geochemical survey, over an area of 5 000 by 1 000 m located a narrow nickel anomaly extending for 2 000 m south-eastwards from the Jacomynspan boundary. The nickel anomaly was found to be associated with serpentinite bodies rarely more than a few metres wide. Towards the south three large masses of serpentinite, from 100 to 200 m thick, were located over strike lengths of 400, 600, and 300 m, respectively.

Twenty-four diamond drill boreholes were drilled to investigate the serpentinite bodies. The succession consists of quartz–mica schist, serpentinite, biotite–tremolite schist, and garnet–biotite gneiss. The biotite–tremolite schist is mineralized, with pyrrhotite constituting up to 15 per cent of the whole rock in places. This unit reaches a maximum thickness of 116 m in the north-west, against the Jacomynspan boundary. The best intersection obtained assayed 0,16 per cent copper and 0,20 per cent nickel over 46 m. The serpentinite lacks significant sulphide mineralization, but in one of the bodies measuring 400 by 100 m, numerous chrysotile asbestos bands were intersected. Fibre ranged up to 2 cm in length (average 2–3 mm) at a grade of less than 0,5 per cent.

Indications are that the pyrrhotite content and the amount of serpentinite increases eastwards onto Hartebeestpan, with a sympathetic drop in nickel and copper grades, thereby explaining the better aeromagnetic and electromagnetic anomalies on that farm in relation to Jacomynspan.

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