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1959/145

REPORT ON DIAMOND DRILLING AT

COSMOPOLITAN HOWLEY MINE, BROCKS CREEK, N.T.

by

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PLATES

SUMMARY

Three diamond drill holes were drilled at the Cosmopolitan Howley Mine to test the downward extension of the "nodular siltstone" beneath No's 1 and 5 Open Cuts and to confirm that this bed is the gold-bearing horizon.

The area tested is on the nose and north limb of a major anticline which plunges to the northwest. The main rocks are diorite, pyritic carbonaceous siltstone and "nodular siltstone" with associated beds of slate, schist and sandstone. The rocks have suffered strong drag-folding.

Recovery of the drill core averaged 80% and the core showed extensive sulphide mineralisation, mainly pyrite. Assay results showed that the "nodular siltstone" beds contained gold. All the gold was not associated with pyrite.

The results warrant further investigation, by the leaseholders, of the extent of the gold ore-body intersected by drill holes No's 2B and 3 and the drag-folded areas between No's 5 and 9 Open Cuts.

INTRODUCTION

During June, 1957, a plane table and alidade survey was made of part of the surface workings of the Cosmopolitan Howley Mine, Brocks Creek. During this survey two sites were selected for the diamond drilling proposed by N.J. MacKay (1956). The two holes were drilled to test the theory that the gold was closely associated with "nodular siltstone" beds. The holes were designed to intersect the "nodular siltstone" beds below the old workings. Drilling commenced in September, 1957, and was completed in February, 1958. D.D.H. No. 1 was 661 feet in length and D.D.H. No. 2B was 341 feet in length.

As a result of the surface mapping and diamond drilling, D.D.H. No. 2B was deepened to 382 feet, and a third diamond drill hole, D.D.H. No. 3, was drilled to intersect the "nodular siltstone" beds below the eastern end of No. 5 Open Cut. This hole, 353 feet in length, was commenced in December, 1958 and completed in March, 1959.

LOCALITY AND ACCESS

The Cosmopolitan Howley Mine lies about 80 miles southsoutheast of Darwin and within the Waggaman Goldfield (see Plate 1). The turnoff to the mine, which is approximately half a mile east of the Stuart Highway, is at the 110 mile peg. Access to the mine from the Highway is by a gravel all-weather road, badly washed out in places.

GEOLOGY

The geology of the area has been dealt with in detail by Sullivan and Iten (1952) but part of the area has been remapped. Drilling and surface mapping have shown that the quartzite is not as extensive as Sullivan has indicated. The rocks belong to the Golden Dyke Formation of Lower Proterozoic Age. The surface geology is shown in Plate 2.

Structural Geology

The dominant structure is a major anticline with a general northwesterly strike and plunge. (See Plate 4). Drag-folds occur on both limbs and the nose of the structure shows intense crumpling. This intense folding has resulted in the crushing and shearing of some of the beds. The "nodular siltstone" beds have been referred to as a "crush conglomerate" (Hossfeld 1942). Gold ore-bodies are associated with this anticline. The workings and their relationship to the anticline can be seen diagrammatically in Plate 4. The anticline is asymmetrical, the north limb dipping steeply at about 75° and the south limb dipping at 55°. Thickening and repetition of beds have probably resulted from the folding.

Stratigraphy

The drill holes were designed to test part of the north limb of the anticline and were aimed to intersect the down-dip extension of the gold ore-bodies in this limb.

Three stratigraphic zones are evident on the north limb of the anticline. They are, youngest rocks at the top, as follows:-

Diorite zone	60'
Zone of carbonaceous siltstone	300'
Zone of "nodular siltstone" and associated beds	120' plus

The thickness of these rocks as seen on the surface and in the drill holes is exaggerated by the drag-folding. However a section showing the true thickness of the strata can be seen in a cutting on the Fountain Head road, close to the Stuart Highway.

Diorite Zone

This zone is comprised of massive diorite with occasional intrusions of quartz and quartz-hematite. Present evidence indicates that the diorite is conformable to the structure. The diorite close to the surface shows extreme weathering. The total depth of weathering is about 80 feet.

Zone of Carbonaceous Siltstone

The beds in this zone are mainly carbonaceous siltstone with interbedded slate, schist and sandstone. Dips taken on the surface and from the drill core range from 55° to 85°, the steeper dips being nearer the nose of the anticline. Certain sections of the carbonaceous siltstone are very rich in pyrite and this is reflected at the surface in outcrops of limonite gossan. These show evidence of box work after pyrite.

Shear zones are evident from the drill core and some can be seen on the surface. One strong shear was seen in the underground workings at the 175 foot level. Some of these shears were quartz filled.

Associated with the shearing are carbonaceous siltstone beds showing drag-folding. Drag-folds can be seen in the drill core and are in evidence on the surface where a site was bulldozed for D.D.H. No. 3. It is apparent that the more plastic carbonaceous siltstone flowed and the pebble beds were sheared during drag-folding. Evidence of faulting is shown by several slickensided surfaces of carbonaceous siltstone coated with graphite.

Zone of "Nodular Siltstone" and Associated Beds

The term "nodular siltstone" refers to the rock type consisting of chert nodules in a matrix of pyritic carbonaceous siltstone and as such will be used in this report. In this zone nodular beds are interbedded with carbonaceous siltstone, sandstone, quartzite, and chiastolite slate. Gold is associated with the nodular beds in this zone particularly where shearing is evident.

A thin bed of chiastolite slate about two feet thick is an important marker bed as it occurs below the pebble bed that has, from surface evidence, contained the most gold ore. The marker bed is shown diagrammatically in Plate 4. This bed can be seen on the southern edge of No. 5 and No. 7 Open Cuts and on the northern edge of No. 3 Open Cut.

Quartz reefs have intruded both the "nodular siltstone" and the pyritic carbonaceous siltstone. From surface evidence most of the intrusions appear to be contemporaneous with the drag-folding but some intrusions may have taken place at a late stage of the folding. Plate 2 shows the extent of the quartz intrusions at the surface. These intrusions are of two types. In one the quartz shows definite boundaries and appears to have resisted weathering to a greater extent than the surrounding rock. In the other the quartz has replaced or assimilated beds and no definite contact can be mapped.

At the eastern end of No. 5 Open Cut the intrusion has assimilated part of the "nodular siltstone". Between No's 7 and 9 Open Cuts the quartz reefs have been drag-folded and faulted. The quartz reefs are considered to be conformable, not transgressive, and some of the quartz intrusions have assimilated nodular beds.

LITHOLOGY

The hornblende diorite (hornblendite) is dark green and medium grained consisting mainly of hornblende; the weathered sections show some alteration to chlorite.

The carbonaceous siltstone includes several shatter zones which post date the folding. These shatter zones have been intruded by quartz and carry pyrite, arsenopyrite, chalcopyrite, pyrrhotite, tourmaline, chlorite, bleached biotite, dolomite and saccharoidal quartz (see Appendix 2). Several slickensided surfaces coated with graphite were seen in the drill core, while other sections of the core show contorted structures which are the result of drag-folding.

Recent mapping has shown that most of the beds previously classified by Sullivan and Iten (1952) as quartzite are in effect nodular beds in which the chert and quartzite lenses vary in size, both laterally and vertically from small nodules the size of marbles to boulders with a diameter of 3 feet. The lateral variation is particularly evident in a bed which cuts across the road on the north side of No. 5 Open Cut. Although the nodular beds are more extensive than was first thought, there are two distinct types of matrix for the nodular beds. In one case the matrix is brown and rich in iron and the nodules are relatively small. The second type of nodular bed has a more distinctive blue-grey carbonaceous matrix and the pebbles are larger. Most of the material mined has been taken from the pebble beds with the blue-grey carbonaceous matrix.

The nodules are of chert or sugary quartzite and are sometimes surrounded by sulphide mineralisation, chiefly pyrite. These beds could be pebble beds in which the original pebbles have been subject to shearing. The term "nodular siltstone" is used throughout this report for this type of rock, and where necessary the type of matrix is indicated.

MINERALOGY

The carbonaceous siltstone is heavily mineralised, particularly with pyrite, in the sections of the drill core from D.D.H. No. 1 (see Plate 3). The core from D.D.H. No 2B showed that the pyrite mineralisation was much less in this hole. The core from D.D.H. No. 3 showed a slight increase in pyrite mineralisation over D.D.H. No. 2B but not as much as in D.D.H. No. 1. Arsenopyrite is associated with the carbonaceous siltstone and the "nodular siltstone", but to a much lesser extent than the pyrite.

The gold occurs mainly in the "nodular siltstone". Assays from D.D.H. No. 1 have shown that although the sulphide mineralisation, particularly pyrite, is high, the gold content of the "nodular siltstone" zone is low. In D.D.H. No. 2B, where assays show that the gold content of the nodular beds is higher, the sulphide mineralisation is much lower. In D.D.H. No. 3, the gold content is lower than the content in D.D.H. No. 2 but the sulphide mineralisation is slightly higher. This indicates that the gold is not associated with pyrite. MacKay (1956) states that panning of the drill cuttings from the north cross cut on the 175 foot level showed free gold. Sections of drill core from drill holes No's 1 and 2B were sent to Canberra for mineragraphic examination. The results are given in Appendices 2 and 3 and they show that some of the gold exists as free gold. This will improve the prospect of future development of the mine if further investigations show that the gold content of the ore is of economic grade and that there is sufficient quantity of ore.

Pyrite fills shear and joint planes and also occurs as bands parallel to the bedding. These bands range in thickness from 1/16 inch to 4 inches. Traces of chalcopyrite are associated with the pyrite but the ratio of chalcopyrite to pyrite is very low.

Coarse crystals of arsenopyrite occur in bands of euhedral crystals parallel to the bedding. Mineragraphic work indicates that the arsenopyrite was present in the rock prior to shearing (see Appendix 2).

DRILLING

Drilling commenced on 19th September, 1957, and D.D.H. No. 1 was completed t 661 feet on 4th December, 1957. Due to trouble with caving and tools jamming, .D.H.'s No. 2 and No. 2A had to be abandoned at about 100 feet. It was then ecided to change the angle of inclination from 60° to 55° and drill a new hole, .D.H. No. 2B. This new hole was stopped at 341 feet after it was thought to have assed through the downward extension of the ore zone. When the assay results were eceived it was decided to deepen this hole, and accordingly the hole was deepened from 41 feet to 382 feet. D.D.H. No. 3 was commenced on the 16th December, 1958 and ompleted on the 12th March, 1959. It was drilled at an inclination of 55° to a otal depth of 352 feet 6 inches.

The core recovery from each hole was very good. In D.D.H. No. 1 the ecovery from 150 feet below the collar to 661 feet was 89%. The first section of the ole was through rubble and weathered rock, and core recovery was not required. In .D.H. No. 2B the core recovery below the rubble and weathered rock was 70%. The ore recovery from D.D.H. No. 3 was 80%.

Cross sections along the three holes are shown in Plate 3, and logs of the rill holes are shown in Appendix 1.

GOLD ASSAY RESULTS

D.D.H. No. 1 Core

Depth below Collar (in feet)	Assay Results (Dwt gold per ton)
420' - 495'	Nil or Trace
495' - 500'	0.51
500' - 505'	0.68
505' - 565'	Nil or Trace
565' - 575'	0.34
575' - 580'	1.02
580' - 585'	0.51
585' - 600'	Trace
600' - 605'	1.02
605' - 610'	0.68
610' - 615'	Nil
615' - 625'	0.68
625' - 630'	1.36
630' - 635'	1.02
635' - 640'	2.72
640' - 645'	Trace
645' - 650'	0.68
650' - 655'	Trace
655' - 661'	1.36

D.D.H. No. 2B Core

Depth below Collar (in feet)	Assay Results (Dwt gold per ton)
264' - 269'	1.36
269' - 274'	4.08
274' - 279'	1.70
279' - 284'	1.36
284' - 289'	6.80
289' - 294'	3.06
294' - 299'	1.36
299' - 319'	Nil or Trace
319' - 325'	0.68
325' - 330'	9.52
330' - 335'	4.76
335' - 341'	12.24
341' - 346'	2.6
346' - 362'	Trace
362' - 367'	0.5
367' - 372'	1.6
372' - 382'	Trace

D.D.H. No. 3 Core

Depth below Collar (in feet)	Assay Results (Dwt gold per ton)
175' - 180'	0.8
180' - 305'	Nil
305' - 310'	0.6
310' - 315'	0.8
315' - 320'	1.0
320' - 325'	6.0
325' - 330'	7.6
330' - 335'	1.2
335' - 352'6"	Nil

From D.D.H. No. 2B and D.D.H. No. 3 the following details are tabulated:

D.D.H. No.	Drill Run	Length	Recovery	True Width	Weighted Assay (Recovery)
2B	269' - 294'	25'	20'2"	20'	3.6 dwt
	325' - 341'	16'	10'7"	13'	8.6 dwt
3	320' - 330'	10'	9'6"	8'	6.8 dwt

N.B. From the drill log of D.D.H. No. 2B, it can be seen that the recovery was poor over the section 335 feet to 341 feet. This showed the highest assay and therefore the gold content might be greater than shown in this table at 8.6 dwt.

Assay results of the sampling by Mt. Isa Mines and Brocks Creek Uranium N.L. at the 175 foot level showed gold associated with the nodular beds. Mt. Isa results were 10.8 dwt gold per ton over 25 feet and Brocks Creek Uranium N.L. showed 12.2 dwt gold per ton over 13 feet or 8.1 dwt gold per ton over 27 feet (MacKay 1956).

Examination of the open cuts revealed that it is mainly the "nodular siltstone" with the blue-grey matrix that has been removed and that practically all rock removed was put through the battery. This was the case with Open Cuts No. 5, 7 and 9.

CONCLUSIONS

Where there is strong sulphide mineralisation the gold content is low. The gold is associated with the "nodular siltstone" beds, particularly those which have been strongly sheared and lie stratigraphically just above the marker bed of chiastolite slate. Drag-folded and crumpled areas show that structural controls played an important part.

The gold ore-body mined from No. 5 Open Cut has been shown by D.D.H. No. 2B and D.D.H. No. 3 to extend to a depth of at least 300 feet. These two drill holes indicate that the grade of the primary gold ore is 7 to 9 dwt per ton. This ore-body was not intersected by D.D.H. No. 1 and probably plunges to the east.

RECOMMENDATIONS

It is recommended that the leaseholders investigate further the gold ore-body underlying No. 5 Open Cut. It is also recommended that attention be paid to the testing of the drag-folded areas between No. 5 and No. 9 Open Cuts.

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APPENDIX 1

Geological Log - D.D.H. No. 1

Cosmopolitan Howley Mine, Brocks Creek, N.T.

	At Surface	At 300'	At 450'	At 600'
Bearing:	180° M	181° M	177° M	183° M
Inclination:	60°	59°	58°	57°
Total Depth:	661'			
Core Recovery:	89% below 150 feet			
Commenced Drilling:	19th September, 1957			
Completed Drilling:	4th December, 1957			

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
0' - 120'	120'0"	10'0"	Broken rubble, red soil, quartz pebbles, decomposed hornblende diorite.	
120' - 136'	16'0"	6'2"	Well-jointed hornblende diorite containing small amounts of pyrite.	
136' - 144'6"	8'6"	3'8"	2'5" decomposed, weathered diorite; 1'3" well-jointed diorite. The hornblende has weathered to chlorite.	
144'6" - 146'	1'6"	1'6"	2½" quartz vein containing hematite; 5" diorite; 1" quartz; 8½" diorite; 1" quartz.	
146' - 150'	4'0"	3'7"	Well-jointed hornblende diorite; the rodk is a dark green medium grained type, almost completely hornblende.	
150' - 155'	5'0"	5'0"	4'0" diorite containing small amounts of pyrite; 8" diorite containing band of arsenopyrite and crystals of pyrite; 4" diorite.	
155' - 160'	5'0"	5'0"	4'3" diorite with occasional patches of quartz and hematite; 9" quartz-hematite.	
160' - 167'	7'0"	3'0"	Zone of shattered diorite.	
167' - 175'	8'0"	8'0"	3'0" diorite; 3'0" weathered diorite; 3" quartz-hematite; 1'9" well-jointed diorite.	
175' - 183'6"	8'6"	8'6"	5'0" diorite; 1" quartz vein and pyrite; 1'0" diorite; 1" quartz veins and scattered pyrite. 2'4" diorite.	
183'6" - 188'	4'6"	2'0"	6" quartz; 1'6" well-jointed diorite with quartz veins and scattered pyrite.	
188' - 200'	12'0"	12'0"	1" quartz veins; 2'1" diorite; 1" quartz; 9'9" diorite.	
200' - 203'	3'0"	3'0"	Diorite.	
203' - 211'	8'0"	8'0"	Jointed diorite showing siliceous material in places.	

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
211' - 215'	4'0"	2'9"	3" quartz-hematite; 2'6" diorite.	
215' - 258'	43'0"	41'0"	Diorite.	
258' - 262'	4'0"	4'0"	3' quartz-hematite-pyrite zone; 1' carbonaceous siltstone with quartz veins and pyrite in fractures.	Less than 5%
262' - 269'	7'0"	7'0"	Carbonaceous siltstone with scattered pyrite bands.	Less than 5%
269' - 273'	4'0"	3'0"	1'0" quartz-hematite zone; 2'0" carbonaceous siltstone.	
273' - 282'	9'0"	9'0"	Carbonaceous siltstone with quartz and pyrite at 274' and 274'10"; bands of hematite at 278'0"; pyrite and hematite at 280'6".	10%-15%
282' - 291'	9'0"	9'0"	Carbonaceous siltstone carrying small quartz veins and pyrite; traces of hematite between 287'6" and 291'.	Less than 5%
291' - 295'	4'0"	4'0"	Carbonaceous siltstone; 292'8"-293'6" with quartz-hematite and some pyrite; pyrite transgresses bedding at 293'6".	5%
295' - 305'	10'0"	10'0"	6" powdery pyrite 9'6" carbonaceous siltstone with quartz veins and pyritic bands.	5%
305' - 309'	4'0"	4'0"	Carbonaceous siltstone with 4" band of pyrite at 307'6"-307'10"; small pyrite bands and quartz veins.	5-10%
309' - 313'6"	4'6"	4'6"	Carbonaceous siltstone with occasional quartz and pyrite.	Less than 5%
313'6" - 322'	8'6"	8'6"	Carbonaceous siltstone with occasional quartz and pyrite; massive pyrite at 314'-314'6"; pyrite filling joint planes at 318'.	5-10%
322' - 327'	5'0"	5'0"	Carbonaceous siltstone with quartz-pyrite zone 323'8" to 324'10".	10%
327' - 334'	7'0"	7'0"	Carbonaceous siltstone carrying pyrite, hematite and arsenopyrite.	10-15%
334' - 338'	4'0"	4'0"	Carbonaceous siltstone with bands of pyrite and quartz.	Less than 5%
338' - 343'	5'0"	4'6"	Carbonaceous siltstone with massive pyrite at 404'6"-405'6"; traces of chalco-pyrite.	20%
343' - 349'	6'0"	6'0"	Carbonaceous siltstone with concentrations of pyrite at 344', 344'3" and 345'3".	Less than 5%

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
349' - 353'	4'0"	4'0"	Carbonaceous siltstone with bands of quartz and pyrite; concentration of pyrite at 352'9".	5%
353' - 356'	3'0"	3'0"	Carbonaceous siltstone with concentrations of pyrite at 353'6", 353'9" and 355'6".	5%
356' - 362'	6'0"	6'0"	Carbonaceous siltstone with traces of pyrite in joints.	Less than 5%
362' - 367'	5'0"	3'6"	Core broken; carbonaceous siltstone with quartz and pyrite.	10-15%
367' - 382'	15'0"	14'0"	Carbonaceous siltstone with occasional quartz and pyrite.	5%
382' - 390'	8'0"	8'0"	Carbonaceous siltstone with bands of pyrite at 382'6", 385', 389'5" and 390'.	5%
390' - 406'	16'0"	13'8"	Carbonaceous siltstone with occasional zones rich in pyrite; some quartz veins; traces of chalcopyrite.	10%
406' - 411'	5'0"	3'8"	Core broken; carbonaceous siltstone.	Less than 5%
411' - 416'	5'0"	3'8"	Carbonaceous siltstone with pyrite at 411' and 414'; quartz vein at 411'6".	5%
416' - 419'	3'0"	3'0"	Carbonaceous siltstone with occasional pyrite.	5%
419' - 424'	5'0"	4'0"	Carbonaceous siltstone with pyrite banding; pyrite concentrated at 413'-424'.	5-10%
424' - 431'	7'0"	6'8"	Carbonaceous siltstone; pyrite content increasing.	25-30%
431' - 444'	13'0"	7'3"	Carbonaceous siltstone with pyrite.	25-30%
444' - 449'	5'0"	4'6"	Carbonaceous siltstone with high pyrite content.	40%
449' - 452'	3'0"	2'6"	Bedding contorted; intra formational deformation; carbonaceous siltstone with pyrite.	25-30%
452' - 460'	8'0"	7'6"	Very broken carbonaceous siltstone with pyrite bands.	20%
460' - 467'6"	7'6"	7'6"	Carbonaceous siltstone with pyrite; pyrite shows signs of leaching.	20-25%
467'6" - 473'	5'6"	3'8"	Carbonaceous siltstone with pyrite; bedding contorted at 472'.	15-20%
473' - 481'6"	8'6"	5'6"	Core broken; carbonaceous siltstone and pyrite.	5-10%

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
481'6" - 485'	3'6"	2'0"	Core broken; carbonaceous siltstone with pyrite and traces of quartz and dolomite; massive pyrite at 485'.	50%
485' - 489'	4'0"	3'10"	Carbonaceous siltstone with high pyrite content; traces of chalcopyrite and dolomite.	60-70%
489' - 495'	6'0"	6'0"	6" massive pyrite 5'6"; carbonaceous siltstone with pyrite and traces of hematite; pyrite shows signs of leaching.	40-50%
495' - 500'	5'0"	4'6"	Carbonaceous siltstone with pyrite; quartz vein at 498'4"; bands of quartz and pyrite at 498'5".	30%
500' - 516'6"	16'6"	13'9"	Carbonaceous siltstone; with pyrite; core broken.	30%
516'6" - 527'	10'6"	10'4"	Carbonaceous siltstone and pyrite; siliceous material 522'6"-527'0"; contorted bedding, intraformational deformation.	25%
527' - 531'	4'0"	3'0"	Carbonaceous siltstone and pyrite.	5%
531' - 541'	10'0"	9'3"	Carbonaceous siltstone; at 535'9" bands of quartz, dolomite and pyrite; 536'3"-541' rich in pyrite.	20%
541' - 542'	1'0"	10"	Carbonaceous siltstone with quartz and thin bands of dolomite.	5%
542' - 544'6"	2'6"	2'4"	Mainly quartz with thin veins of dolomite, scattered pyrite and traces of hematite.	5%
544'6" - 548'	3'6"	2'2"	Carbonaceous siltstone with thin veins of quartz, dolomite and pyrite.	5%
548' - 554'	6'0"	6'0"	Carbonaceous siltstone; 548'3" pyrite; 548'6"-548'10" quartz pyrite and dolomite; 551'3" carbonaceous siltstone with contorted bedding; 553'8" pyrite.	25-30%
554' - 560'8"	6'8"	6'5"	"Nodular siltstone", (Chert nodules in carbonaceous pyritic siltstone). Some pyrite and dolomite; traces of chalcopyrite.	25-30%
560' - 571'6"	11'6"	8'6"	White quartz with traces of pyrite, arsenopyrite and dolomite.	Less than 5%
571'6" - 575'	3'6"	3'6"	Dark green fibrous basic rock carrying pyrite.	15-20%
575' - 584'	9'0"	8'10"	"Nodular siltstone" with some pyrite.	15%

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
584' - 599'	15'0"	13'9"	"Nodular siltstone", high pyrite content.	25-30%
599' - 601'	2'0"	2'0"	"Nodular siltstone" with bands of arsenopyrite.	5%
601' - 615'	14'0"	12'9"	Carbonaceous siltstone with dolomite, pyrite, and quartz; bands of coarsely-crystalline arsenopyrite.	10%
615' - 625'	10'0"	10'0"	Altered carbonaceous siltstone rich in arsenopyrite; traces of pyrite and quartz.	25%
625' - 634'	9'0"	8'10"	"Nodular siltstone" with pyrite.	15-20%
634' - 636'	2'0"	1'6"	Carbonaceous siltstone with traces of pyrite.	Less than 5%
636' - 644'	8'0"	2'6"	Very broken core; altered carbonaceous siltstone; some dolomite, pyrite and arsenopyrite.	15%
644' - 646'	2'0"	1'10"	Broken carbonaceous siltstone.	Less than 5%
646' - 653'	7'0"	5'11"	Altered carbonaceous siltstone with arsenopyrite, pyrite and quartz.	10-15%
653' - 661'	8'0"	6'5"	Broken carbonaceous siltstone with traces of pyrite and arsenopyrite.	Less than 5%

Geological Log - D.D.H. No. 2B

Cosmopolitan Howley Mine, Brocks Creek, N.T.

(N.B. D.D.H. No. 2 and No. 2A were both abandoned at about 100 feet depth due to caving and drill rods jamming in the lode.)

	At Surface	At 100'	At 194'	At 330'
Bearing:	180° M	181° M	180° M	179° M
Inclination:	55°	56°	54°	53°

Total Depth: 382'
Core Recovery: 70% below 85 feet
Commenced Drilling: 28th December, 1957, 8th November, 1958
Completed Drilling: 6th March, 1958, 29th November, 1958

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
0' - 40'	40'0"	3'0"	Rubble, red soil, decomposed hornblende diorite.	
40' - 67'	27'0"	5'6"	Weathered diorite (the hornblende is weathered to diorite).	
67' - 85'	18'0"	2'0"	Very broken weathered diorite.	
85' - 91'	6'0"	4'0"	2' weathered diorite; 2' horblende diorite (dark green medium grained material, almost completely hornblende).	

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
91' - 95'	4'0"	2'0"	Hornblende diorite, weathered on joints; quartz at 95'.	
95' - 98'	3'0"	3'0"	Hornblende diorite; quartz-hematite at 97'6".	
98' - 120'	22'0"	18'6"	Hornblende diorite, weathered on joint planes.	
120' - 124'	4'0"	2'4"	Carbonaceous siltstone; traces of kaolin and pyrite.	Less than 1%
124' - 130'	6'0"	3'6"	Carbonaceous siltstone, broken at 125'.	
130' - 131'	1'0"	1'0"	Carbonaceous siltstone.	
131' - 132'	1'0"	3"	Quartz hematite, shattered zone.	
132' - 134'	2'0"	1'9"	9" shattered carbonaceous siltstone; 1' carbonaceous siltstone with traces of pyrite.	Less than 5%.
134' - 139'	5'0"	4'6"	Carbonaceous siltstone with very thin bands of pyrite, and traces of kaolin.	Less than 5%
139' - 142'	3'0"	3'0"	Carbonaceous siltstone with lens of sandstone at 139'4"-139'8"; carbonaceous siltstone shattered at 141'.	
142' - 145'	3'0"	2'0"	Carbonaceous siltstone with traces of pyrite and kaolin.	
145' - 150'	5'0"	4'0"	Carbonaceous siltstone with traces of kaolin; pyrite at 146'6".	
150' - 158'	8'0"	4'0"	Carbonaceous siltstone, shattered at 150'. Traces of pyrite.	Less than 5%
158' - 161'	3'0"	1'10"	Carbonaceous siltstone with thin bands of pyrite. Shattered zone at 158'.	Less than 5%
161' - 165'	4'0"	2'3"	Carbonaceous siltstone, shattered from 162'-165'.	
165' - 167'	2'0"	-	No core; shear zone, probably quartz filled.	
167' - 170'	3'0"	8"	Pieces of quartz filling shear zone.	
170' - 172'	2'0"	1'0"	Sheared carbonaceous siltstone.	
172' - 174'	2'0"	10"	Sheared carbonaceous siltstone with traces of pyrite.	
174' - 184'	10'0"	9'2"	Carbonaceous siltstone with pyrite.	5%
184' - 187'	3'0"	2'3"	Broken carbonaceous siltstone; pyrite at 184'.	5-10%
187' - 192'	5'0"	3'4"	Broken carbonaceous siltstone.	Less than 5%
192' - 197'	5'0"	4'0"	Sandstone carrying hematite and slaty lenses. Traces of pyrite.	Less than 5%

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
197' - 200'	3'0"	2'4"	Very broken carbonaceous siltstone with hematite and pyrite.	
200' - 202'	2'0"	1'7"	1' carbonaceous siltstone; 7" sandstone.	
202' - 204'	2'0"	1'3"	Carbonaceous siltstone with pyrite.	
204' - 207'	3'0"	2'9"	Very broken carbonaceous siltstone with traces of dolomite and kaolin.	
207' - 211'	4'0"	2'9"	Very broken carbonaceous siltstone.	
211' - 216'	5'0"	-	No core; sludge very pyritic.	
216' - 224'	8'0"	3'5"	Very broken carbonaceous siltstone.	
224' - 227'	3'0"	2'6"	Soft carbonaceous siltstone.	
227' - 237'	10'0"	6'2"	Sheared carbonaceous siltstone; sludge very pyritic.	
240' - 241'	1'0"	8"	Sheared carbonaceous siltstone.	
241' - 244'	3'0"	2'4"	Carbonaceous siltstone with dolomite.	
244' - 246'	2'0"	6"	Very broken carbonaceous siltstone with traces of pyrite and chalcopyrite.	Less than 5%
246' - 248'	2'0"	1'0"	Very broken carbonaceous siltstone.	
248' - 256'	8'0"	6'11"	Carbonaceous siltstone with small amounts of pyrite.	Less than 5%
256' - 260'	4'0"	3'0"	Broken carbonaceous siltstone.	
260' - 261'	1'0"	-	No core; probable shear zone.	
261' - 264'	3'0"	1'2"	Broken carbonaceous siltstone.	
264' - 265'	1'0"	10"	"Nodular siltstone". (Chert nodules in carbonaceous, pyritic siltstone).	
265' - 267'	2'0"	1'5"	"Nodular siltstone". (Chert nodules in carbonaceous, pyritic siltstone).	
267' - 268'	1'0"	7"	"Nodular siltstone". (Chert nodules in carbonaceous, pyritic siltstone).	
268' - 270'	2'0"	1'1"	"Nodular siltstone". (Chert nodules in carbonaceous, pyritic siltstone).	
270' - 272'	2'0"	1'3"	"Nodular siltstone" and pyrite.	Less than 5%
272' - 274'	2'0"	2'0"	Very broken carbonaceous siltstone with traces of pyrite and arsenopyrite.	Less than 5%

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
274' - 276'	2'0"	6"	Broken quartz with traces of pyrite	Less than 5%.
276' - 277'	1'0"	1'0"	Carbonaceous siltstone and pyrite.	5%
277' - 281'	4'0"	2'9"	Sheared carbonaceous siltstone.	
281' - 284'	3'0"	3'0"	Sandstone with traces of pyrite.	5%
284' - 291'	7'0"	7'0"	"Nodular siltstone".	
291' - 304'7"	13'7"	12'2"	White quartz with scattered pyrite - some patches of sheared siltstone.	
304'7" - 313'	8'5"	7'9"	Carbonaceous siltstone, some quartz.	
313' - 318'	5'0"	3'10"	"Nodular siltstone".	
318' - 320'	2'0"	2'0"	Sandstone.	
320' - 323'	3'0"	1'10"	"Nodular siltstone".	
323' - 326'	3'0"	2'9"	Carbonaceous siltstone.	
326' - 342'6"	16'6"	10'6"	"Nodular siltstone".	
342'6" - 343'6"	1'0"	1'0"	Carbonaceous siltstone with quartz stringers disseminated pyrite.	10%
343'6" - 344'9"	1'3"	11"	Carbonaceous siltstone with traces of pyrite and quartz.	5%
344'9" - 346'	1'3"	1'0"	Quartz with small bands of pyrite.	5%
346' - 351'6"	5'6"	5'0"	Carbonaceous siltstone with occasional small quartz veins. Traces of pyrite.	Less than 5%
351'6" - 361'10"	10'4"	10'0"	Carbonaceous siltstone with quartz veins, small bands of pyrite and arsenopyrite.	5%
361'10" - 374'6"	12'8"	12'0"	Sheared carbonaceous siltstone.	
374'6" - 375'2"	8"	8"	Pyritic carbonaceous siltstone with chert nodules.	Less than 5%
375'2" - 382'	6'10"	6'8"	Carbonaceous siltstone with occasional quartz veins.	

Geological Log - D.D.H. No. 3

Cosmopolitan Howley Mine, Brocks Creek, N.T.

	At Surface	At 345'
Bearing:	180° M	176° M
Inclination:	55°	51°
Total Depth:	352'6"	
Core Recovery:	80%	
Commenced Drilling:	16th December, 1958	
Completed Drilling:	12th March, 1959	

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
0' - 30'	30'0"	25'0"	Carbonaceous siltstone, black - with vuggy limonitic boxwork every 4 or 5 inches.	
30' - 45'	15'0"	10'6"	Carbonaceous siltstone, black - with red limonitic areas showing vuggy boxwork - very broken.	
45' - 48'	3'0"	1'3"	Carbonaceous siltstone, black - very friable.	
48' - 64'	16'0"	11'6"	Carbonaceous siltstone, black - with thin yellow and white quartz stringers ($\frac{1}{8}$") running parallel with core - boxwork vugs increase to 10%.	
64' - 113'	49'0"	34'0"	Carbonaceous siltstone, black - with tiny quartz stringers - prominent boxwork vugs from 69' to 73'.	
113' - 117'	4'0"	3'8"	Carbonaceous siltstone, black - tight with no vugs, solid bands of pyrite in the bedding (4" at 115', 2" at 115'6" and 3" and 117'6") intimately mixed with stringers of white quartz.	20%
117' - 132'	15'0"	14'6"	Carbonaceous siltstone, black - with many thin bands of quartz and pyrite, tightly folded at 125'.	20%
132' - 169'	37'0"	32'6"	Carbonaceous siltstone, black - with many thin bands of quartz and pyrite - ptygmatic folding. Average angle of banding to core is 50°. At 132' - broken quartz At 133' - folded quartz zone, light grey At 137' - 6" of tightly folded rock traced by $\frac{1}{8}$" quartz stringers At 144' - quartz with scattered pyrite At 146' - quartz with scattered pyrite At 161' - 6" white quartz with 40% pyrite.	10%
169' - 180'	11'0"	9'0"	Carbonaceous siltstone, dark grey - high pyrite content disseminated in bands - strong ptygmatic folding	25%
180' - 183'	3'0"	2'10"	"Nodular siltstone" - grey carbonaceous siltstone with scattered nodules of sugary quartz.	
183' - 185'	2'0"	1'11"	Silty schist, grey, banded - no nodules.	

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
185' - 191'	6'0"	5'6"	Speckled schist, red, banded - with scattered quartz nodules and disseminated pyrite.	10%
191' - 196'	5'0"	4'9"	Silty schist, grey, banded - some disseminated pyrite.	5%
196' - 202'	6'0"	5'6"	Quartz, grey, massive - with blobs of coarse and fine pyrite.	15%
202' - 207'6"	5'6"	4'6"	Carbonaceous siltstone, black, very graphitic - strongly sheared.	
207'6" - 212'	4'6"	4'1"	Quartz, grey, massive - with some blobs of pyrite and patches of sheared and folded siltstone.	10%
212' - 218'6"	6'6"	4'9"	Quartz, white, massive - very broken and containing blobs of pyrite.	15%
218'6" - 228'	9'6"	6'3"	Carbonaceous siltstone, black very graphitic - abundand pyrite between 221' and 226'.	25%
228' - 237'	9'0"	8'6"	Carbonaceous siltstone, grey - strongly contorted bedding, many thin parallel stringers of pyrite.	25%
237' - 266'6"	29'6"	25'9"	Carbonaceous siltstone, black, very graphitic - contorted bedding, many thin parallel stringers of quartz and pyrite. At 240'-241'6" - Quartz, white At 263'-264' - Quartz, grey, massive.	15%
266'6" - 269'	2'6"	2'0"	Quartz, grey, massive - with patches of sheared carbonaceous siltstone.	
269' - 271'6"	2'6"	1'9"	Carbonaceous siltstone, black - with scattered thin parallel stringers of quartz and pyrite.	10%
271'6" - 307'	35'6"	25'6"	Carbonaceous siltstone, black, very graphitic - very flaky.	
307' - 309'6"	2'6"	2'0"	Carbonaceous siltstone, black, very graphitic - high pyrite content.	15%
309'6" - 336'	26'6"	19'3"	"Nodular siltstone" - grey siltstone with scattered quartz nodules and disseminated pyrite. Nodules ½" to 2" in width. Contorted bedding. At 320'-320'4" - Arsenopyrite crystals. At 324'2"-324'8" - Arsenopyrite crystals.	10%

DRILL RUN	FOOTAGE DRILLED	FOOTAGE RECOVERED	CORE DETAILS	PERCENTAGE SULPHIDE
336' - 348'	12'0"	9'9"	Carbonaceous siltstone, grey - broken and vuggy, low pyrite content.	5%
348' - 352'3"	4'3"	4'3"	Siltstone, grey - with scattered blobs of quartz (? nodules).	5%
352'3" - 352'6"	3"	3"	Quartz with blobs of pyrite.	10%

APPENDIX 2

EXAMINATION OF DRILL CORES FROM THE COSMOPOLITAN HOWLEY MINE, BROCKS CREEK, N.T.

by

W.M.B. Roberts

D.D.H. 1. 582'

This section of core consists mainly of a fine grained saccharoidal quartz and lenses of a greenish black fine grained material containing sulphide minerals and occasional veins of dolomite.

Quartz, chlorite and dolomite are the principal non-opaque constituents of the section. A mineral closely resembling chlorite having a high D.R., too high for chlorite, is probably bleached biotite.

The quartz has a uniform grain size, averaging 0.08 mm. across, and a mosaic texture. It forms large masses which in places have clearly defined edges and in others merges imperceptibly into the chlorite. This latter mineral forms a felted mass of bladed and sheaf-like aggregates intimately intergrown with a mineral having a very similar appearance but which has a very high D.R. This mineral could not be definitely identified, but is thought to be bleached biotite. The section is uniformly massive; no directional structure is evident.

Dolomite is present as irregular areas up to 0.75 mm. across, and has small veins, and is mainly confined to the quartz-rich parts of the core. The sulphide minerals are pyrite, chalcopyrite, arsenopyrite and pyrrhotite, in that order of abundance. Crystals of pyrite up to 0.4 mm. across occur in the quartz areas, but the principal occurrence of this mineral is as irregular masses in the chlorite. Dolomite is closely associated with the quartz, although occasionally it appears with the chlorite. Chalcopyrite is very sporadic in occurrence, and forms irregular areas in dolomite, some of which are moulding pyrite.

Pyrrhotite is a very minor constituent, forming very small blobs in the pyrite, the largest of which measures 0.012 mm. across.

D.D.H. 1. 557'.

Texturally this section is identical with D.D.H. 1. 582'. The mineral assemblage is similar except that muscovite is present in place of bleached biotite. The muscovite occurs as lath-like crystals up to 0.2 mm. in length which form felted aggregates, principally in the chlorite areas, associated with pyrite.

Pyrite and chalcopyrite are the principal opaque minerals, some graphite is present along small shears. The only difference between this section and D.D.H. 1. 582' is that the ratio chalcopyrite to pyrite has increased, although the former mineral still occurs as a very minor constituent.

D.D.H. 1. 646'

The section is composed of a greenish-black fine-grained material containing lenses of saccharoidal quartz, bands of coarsely-crystalline arsenopyrite, and bands of fine-grained pyrite. The mineral assemblage is quartz, chlorite, pyrite, arsenopyrite, dolomite and tourmaline.

The quartz has a mosaic texture with a grainsize up to 0.5 mm. across, and although it is present chiefly in the form of lenses, a minor amount is distributed throughout the rock. Chlorite is uniformly fine-grained, consisting of a dense mass of radial aggregates intergrown with fine-grained quartz. Tourmaline is present principally as fine needles in the quartz, although an occasional crystal occurs in the chlorite. The largest crystal measures 0.3 mm. in length.

Aside from a small shear cutting the section there is no directional structure in the rock. Some carbonate (dolomite) was observed in the polished section, although none could be seen in the thin section examined.

Pyrite is fine-grained and forms irregular borders to the quartz lenses. It is strung out as thin bands along thin, but persistent shears which make an acute angle with the side of the core. It moulds euhedral arsenopyrite but does not appear to be replacing it. The arsenopyrite forms bands of euhedral crystals in the chlorite sections of the rock. The crystals themselves have a random arrangement and the largest measures 1.0 cm. across. They are strongly fractured and have a "parquet-like" twinning when viewed in polarised light. These facts suggest that arsenopyrite was present in the rock prior to the shearing, which has caused a strong fracturing and twinning in the mineral.

Wherever a quartz lens comes into contact with a band of arsenopyrite crystals, the outline of the lens is continuous and the crystals are truncated sharply against it. Small crystals of arsenopyrite in the thin shear fillings of pyrite are entirely preserved, and only show corrosion when in contact with quartz. Chalcopyrite is a very minor constituent, the largest irregular area measuring 0.01 mm. across.

Certain major facts are evident from the examination of these sections which give an indication of the history of the ore deposition; they are:

1. Bands of strongly fractured arsenopyrite crystals are truncated by quartz lenses.

2. Sulphide minerals (except arsenopyrite) form rims along the quartz lens boundaries, and bands in the rock parallel to the quartz lenses, chiefly associated with chlorite.

3. No texture of the original rock, and only traces of the original minerals remain, e.g. ?bleached biotite in sect. D.D.H. 1. 582'.

4. The bulk of the tourmaline in the rock is present as small needles in the quartz.

These facts suggest that the deposit is of metasomatic origin, where a rock containing crystals of arsenopyrite, arranged either along a bedding or cleavage, has been sheared and a mineralising fluid introduced along the shear planes. The nature of the original rock cannot be determined with certainty, but the present high percentage of chlorite suggests it was probably an argillaceous rock containing a high percentage of biotite.

The introduced solutions carried mainly quartz, which has formed lenses along the shears, CO_2 and sulphide compounds which have reacted with the iron-bearing silicates to give the iron sulphides. The iron-rich silicate, probably biotite was altered to chlorite during the process. Traces of copper in the solution would give the small quantity of chalcopyrite present. The reason for suggesting that the metasome contained sulphide compounds rather than the iron sulphides, is that the sulphide minerals have formed along the edges of the quartz lenses and along shears where solutions could move readily, and hence react with the iron silicates. Very little sulphide is present in the actual quartz, the bulk of it is close to or intergrown with the chlorite mass.

Goldschmidt has suggested that such an association of sulphides in a magnesium-iron-silica assemblage is the result of high temperature metasomatism in which the association of graphite and sulphides is due to the reaction between ferruginous silicates and volatile compounds of carbon and sulphur, such as CS_2 and COS.

APPENDIX 3

EXAMINATION OF CORES FROM THE COSMOPOLITAN HOWLEY MINE

D.D.H. NO. 2B, N.T.

by

W.M.B. Roberts

Four sections of core were submitted by N.J. MacKay, of the Darwin office, for determination of the nature of the gold occurrence.

Three of the rocks (D.D.H. No. 2B, 329' and 289'), are quartz-chlorite schists consisting of even-grained, mosaic-textured quartz intergrown with chlorite, and containing a minor quantity of sericite.

The fourth rock (D.D.H. No. 2B, 286' is a chlorite schist of fine to medium grainsize containing some sericite and a very minor amount of tourmaline.

Pyrite, arsenopyrite, and gold are the only ore minerals in the cores. Pyrite is present in all sections where it forms strongly fractured, irregular masses distributed fairly evenly throughout, and forming as much as 15-20% of the total mineral content of the specimen. The only specimen containing arsenopyrite is that from D.D.H. No. 2B at 289', in which this mineral forms subhedral crystals measuring up to 4.0 mm. across associated with quartz.

These crystals are moulded by pyrite, and the section differs from the others in that the pyrite is not randomly distributed, but is formed as a selvedge along large quartz areas in the rock. No gold could be observed in the sections until the were magnified to X 1050, when it could be positively identified in only one section (D.D.H. No. 2B 327') as small grains in quartz. These grains ranged from 1 to 3 microns in size and are very sporadic in occurrence.

What was thought to be gold was observed in the pyrite of specimen D.D.H. 2B 329', but at extreme magnification the reflectivity of the pyrite tends to make identification of such extremely fine grains very doubtful.

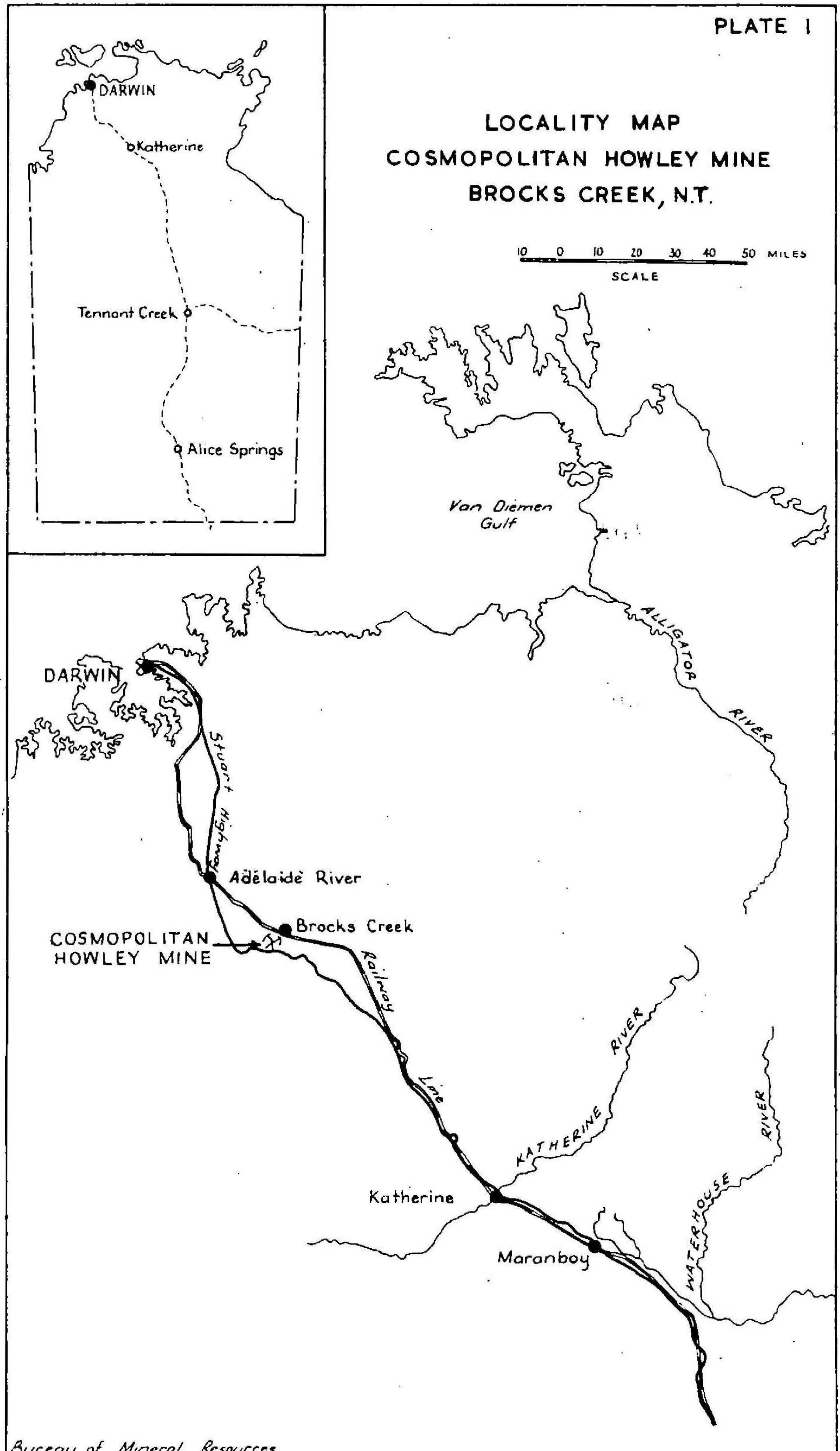
The two cores said to contain gold were crushed to -200 mesh and separated with heavy liquid, and the heavy fraction analysed on the X-ray spectrograph. One line for gold could be observed, (the others are obscured by the spectrum of the tungsten tube) and although this is not sufficient on its own, coupled with the microscopic evidence, it indicated the presence of gold in this fraction.

The heavy fraction was put on the superpanner, and after prolonged operation no gold could be separated. This is probably due to its extremely fine grain-size, and would indicate that the standard methods of gravity separation would recover very little of the total gold in the ore. Also because of this fine grain-size, the ore would have to be crushed to a fineness of 1 micron to release the smallest grains of gold in the quartz. In addition, if there is a substantial amount of gold in the pyrite, the ore would have to be roasted before cyanidation to permit extraction.

In the earlier operation of this mine it is possible that the gold was more easily extracted because in the oxidized zone it would tend to form coarser aggregates in the weathering of the host mineral or minerals.

In addition it is possible that the gold forms coarser grains in the primary ore, and that the specimen examined is not representative.

PLATE I

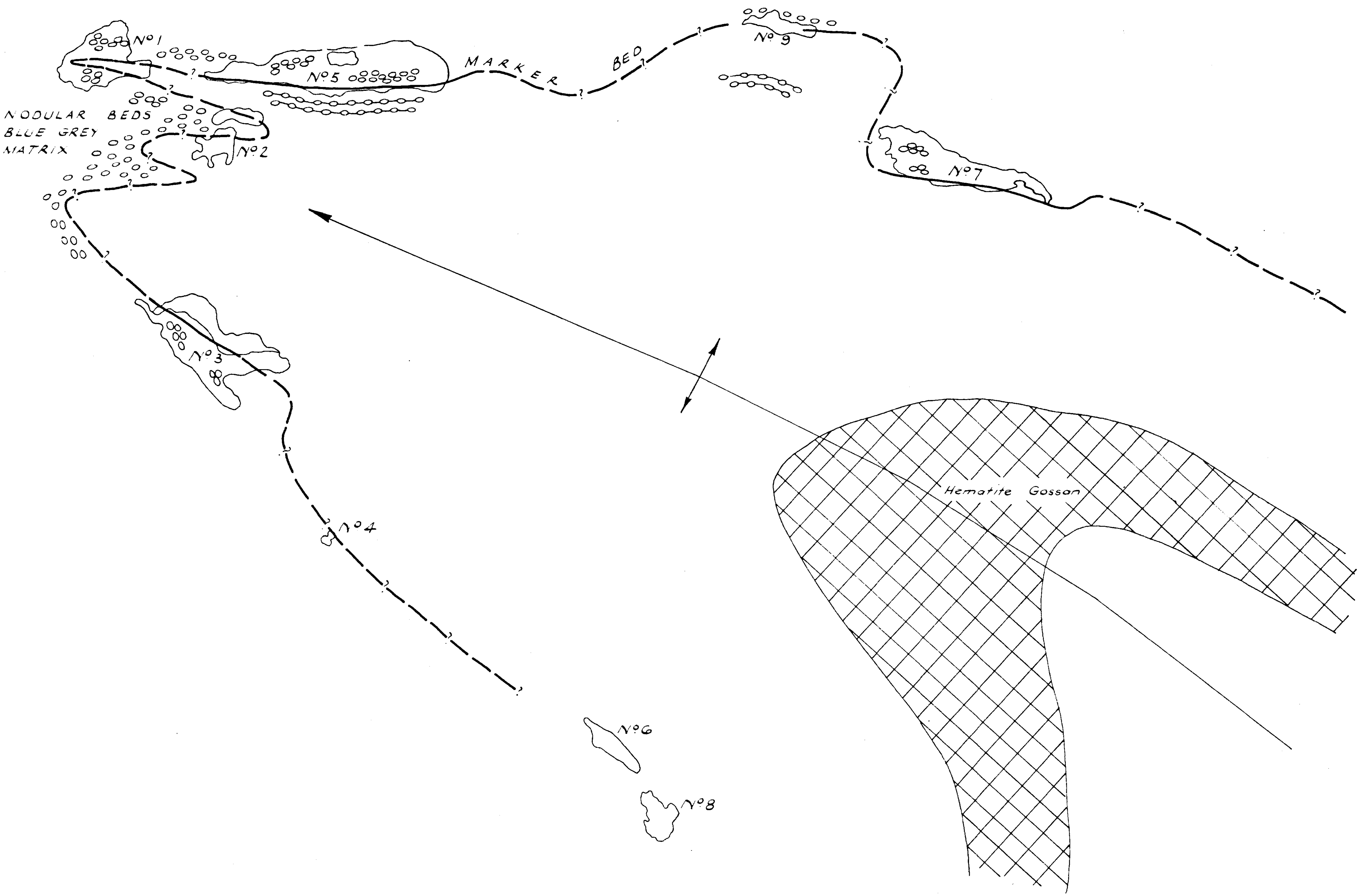


Bureau of Mineral Resources
Resident Geologist's Office, Darwin, July, 1958.

PLATE 2
GEOLOGICAL MAP
COSMOPOLITAN HOWLEY MINE
BROCKS CREEK, N.T.
PLANE TABLE AND ALIDADE SURVEY BY W.F. McQUEEN
GEOLOGY BY W.F. McQUEEN & C.R. MERCER
SCALE
40 20 0 40 80 120 FEET
REFERENCE
Alluvium, surface rubble, detritus.
Diorite
Siltstone, carbonaceous, pyritic.
Hematite gossan.
Banded schist
Nodular siltstone with blue-grey matrix.
Nodular siltstone with brown matrix.
Chiastolite slate
Quartz reef
Section line
Geological boundary (position accurate)
Geological boundary (position approximate)
Geological boundary (position inferred)
Outcrop boundary.
Fault
Main shaft
Shafts.
Costean
DDH3
Diamond drill hole.
Dump
Open cut, pit
Track
Anticlinal fold
Dip & strike of strata.
Contour line (in feet) datum arbitrary.)
Bureau of Mineral Resources
Resident Geologists' Office,
Darwin, N.T. June, 1959.
DDH 1
DDH 2B
DDH 3
Strong drag folding
Strong drag folding
Drag folded Beds Nodular
Dragfolded Nodular Beds
Dragfolded Nodular Beds
Contorted Nodular Beds and Carbonaceous Siltstone
Scattered Alluvial Workings
No. 1
No. 2
No. 5
No. 7
No. 9
No 2

PLATE 3
A
B
DDH No.1
C
No.5 OPEN CUT
DDH No. 2 B
D
E
DDH No. 3
F
DATUM LINE 150' CONTOUR
175' LEVEL
(PROJECTED)
GOLD ASSAY RESULTS DWT PER TON
High Sulphide content mainly Pyrite
REFERENCE
Diorite
Siltstone, pyritic carbonaceous.
Hematite gosson
Banded schist
Nodular siltstone with blue-grey matrix
Nodular siltstone with brown matrix
Chiastolite slate.
Sandstone
Quartz reef
CROSS SECTIONS
ALONG DIAMOND DRILL HOLES Nos. 1, 2B & 3
COSMOPOLITAN HOWLEY MINE
BROCKS CREEK, N.T.
40 20 0 40 80 120 160 FEET
SCALE
Resident Geologists Office
Bureau of Mineral Resources
Darwin, N.T. May, 1959.

PLATE 4



DIAGRAMMATIC SKETCH SHOWING
GENERALISED STRUCTURAL GEOLOGY AND RELATIONSHIP OF
MARKER BED TO NODULAR BEDS.