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DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1975/84

METALLIFEROUS DIAMOND DRILLING, MOUNT ISA AREA, 1971

by

R.M. Hill and B.A. Duff

BMR PUBLICATIONS COMPACTUS
(LENDING SECTION)

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SUMMARY

Three shallow diamond-drill holes, BMR Cloncurry 3, 4, and 5, were drilled in 1971 into the Eastern Succession of the Proterozoic Cloncurry Complex to investigate problems generated by 1:100 000 geological mapping and a detailed aeromagnetic survey in the region.

BMR Cloncurry 3 was drilled to determine the cause of a magnetic anomaly; only dolerite was intersected, and the main objective of the hole was not attained. BMR Cloncurry 4 was drilled to determine the nature of the contact between the Corella Formation and Marimo Slate; altered siltstone and shale were encountered, but the contact was not identified. BMR Cloncurry 5 was drilled in a black pyrrhotite shale in the upper Corella Formation to determine the type and extent of mineralization and to obtain fresh core for geochemical analysis; throughout the shale pyrrhotite, pyrite, and minor sphalerite occur as lenses mantled by gypsum and calcite, and also as veins, distinct layers, and disseminated crystals. The presence of stromatolites, evaporitic minerals, and a high carbon content indicate that the shales were deposited in a hypersaline intertidal zone or a restricted lagoonal environment.

INTRODUCTION

General

Shallow diamond drilling with a BMR Foxmobile rig was carried out in the Eastern Succession of the Proterozoic Cloncurry Complex (Carter et al., 1961) in the Cloncurry 1:250 000 Sheet area, northwest Queensland, during September and October 1971. Three holes were drilled to an aggregate depth of 160 m (514'10"). Continuous BQ ($1\frac{3}{8}$" diameter) core was taken for the whole length of each hole, except in alluvium and deeply weathered rock near the top of each hole; a total of 135 m (433') of coring was done, and 76 m (248') of core - an average of 57 percent - was recovered.

The program was generated from semidetailed regional mapping of the Marraba and Mary Kathleen 1:100 000 Sheet areas in 1969 and 1970 respectively (Derrick et al., 1971; Derrick et al., 1974), and a detailed aeromagnetic survey (Lambourn & Shelley, 1972). The specific objectives for each hole are given in the descriptions of individual holes.

Localities of the drill holes, Cloncurry 3, 4, and 5, are shown in Figure 1, and are also plotted on the relevant Preliminary (1972) Editions of the 1:100 000 Geological Map Series. Naming of the holes is by 1:250 000 Sheet areas - i.e., BMR Cloncurry 4 refers to the fourth hole drilled by BMR in the Cloncurry 1:250 000 Sheet area.

Cloncurry 3 and 4 were logged in the field; because of the uniform nature of the rocks and poor recovery, no further work on these holes was considered necessary. Cloncurry 5 was logged in detail by B.A. Duff in the BMR Core and Cuttings Laboratory, Fyshwick, A.C.T., and material was selected for geochemical investigation. The results and interpretation of the geochemical data and the textures of the sulphides in Cloncurry 5 are reported separately (Duff, in prep.). The cores are stored at the Fyshwick laboratory.

BOREHOLE DATA

BMR Cloncurry 3

Position: Lat. 20°45'50"S, long. 140°24'40"E, 12 km southwest of Cloncurry, 5 km south of the Barkly Highway, about 100 m east of the Malbon Road; Cloncurry 1:250 000 Sheet area (F/54-2), Marraba 1:100 000 Sheet area (6956).

Local Geology:

The drill hole is located on the eastern limb of the Duck Creek Anticline in an area covered by alluvium and soil (Fig. 2). About 0.5 km to the west are outcrops of strongly folded Overhang Jaspilite; to the east are outcrops of the lower member of the Corella Formation. The metasediments near the drill hole are intensely folded, and dips are variable, but overall local dip is about 45° to the northeast (Derrick et al., 1971).

A detailed aeromagnetic survey showed four large magnetic anomalies ranging up to 5400 gammas in amplitude in this area (Lambourn & Shelley, 1972). The major anomalies are shown in Figure 2.

Objectives:

The hole was planned primarily to determine the cause of one of the magnetic anomalies; as soon as the cause of the anomaly was known, the hole was to be stopped. It was also hoped that the drill hole would intersect the contact between the Overhang Jaspilite and the Corella Formation.

Drilling Details:

Direction and inclination	: vertical
Date commenced	: 13 Sept. 1971
Date completed	: 21 Sept. 1971
Final Depth	: 79'4"

LOCALITY MAP

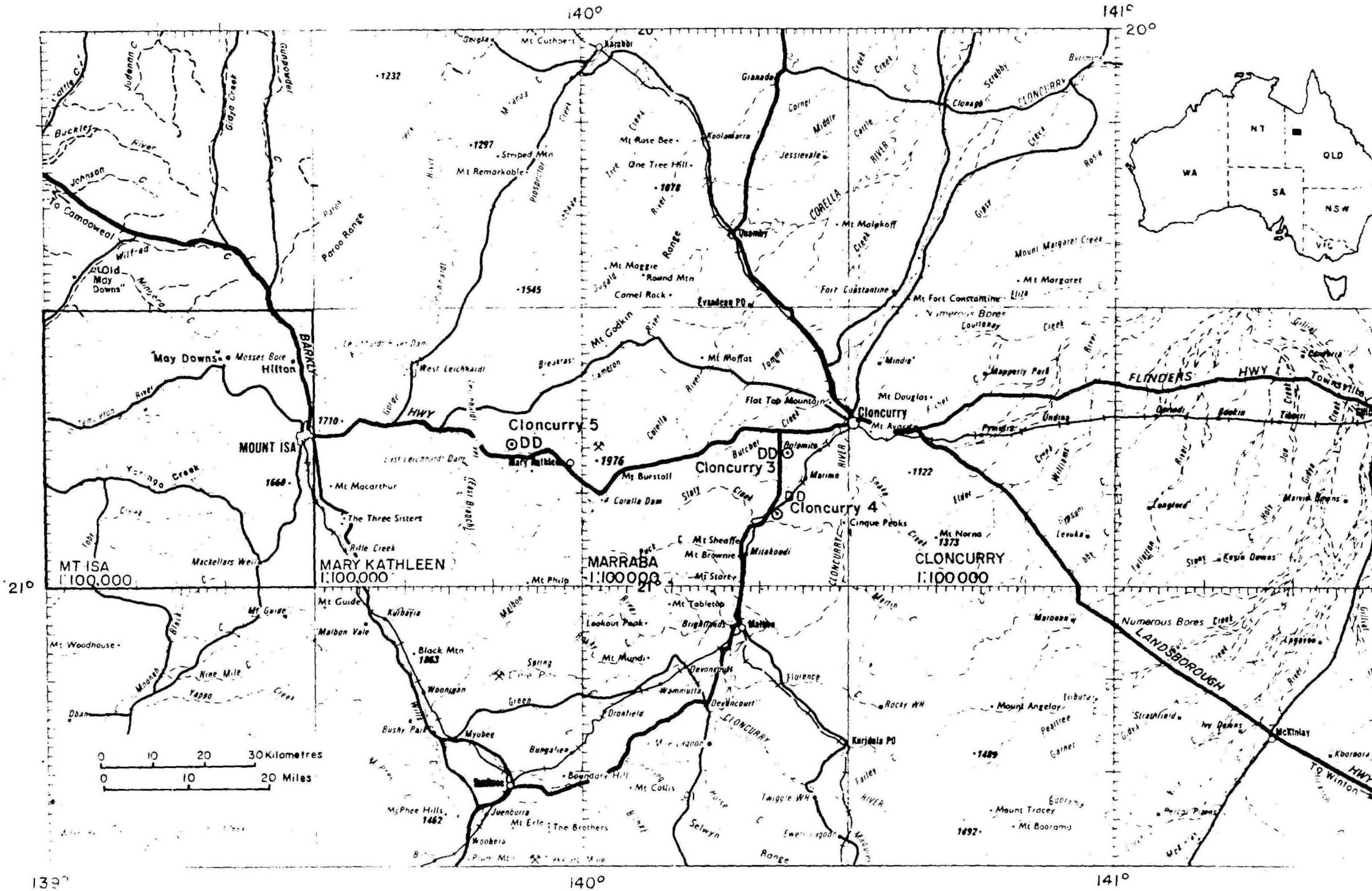

FIG. 1

To accompany Record 1975/84

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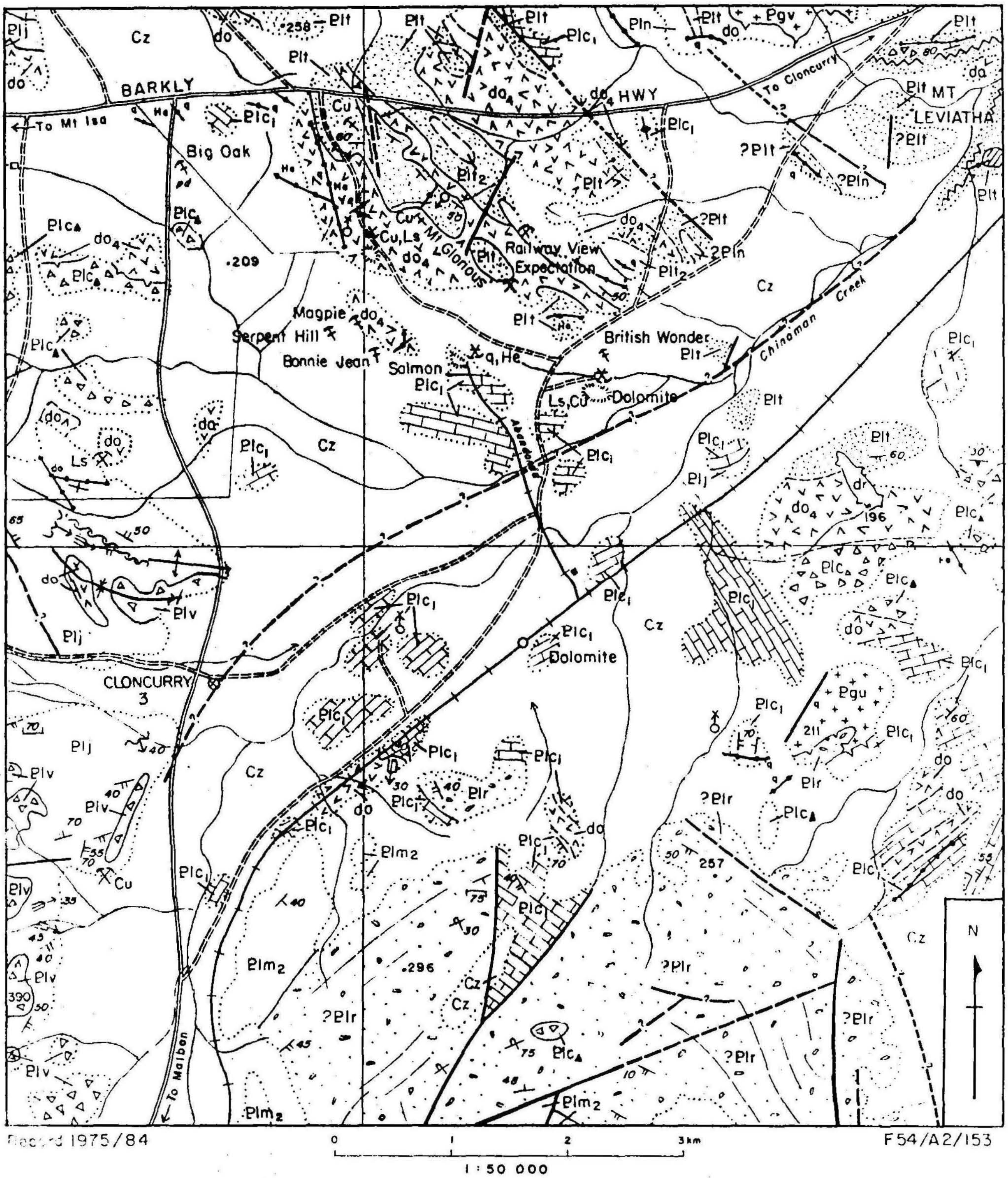

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CAINOZOIC		Cz	Alluvium
PROTEROZOIC	Naraku Granite	Pgu	Leucogranite
		do4	Dolerite
	Roxmere Qtzite	Plr	Feld. qtzite.
		Plm2	F-m. qtzite.
	Corella Formation	Plc▲	Calcareous breccia
		Plc	Calcareous granofels
		Plc2	Calcareous sandstone
		Plc1	Calc-silicate granofes
PROTEROZOIC	Chumvale Br.	Plv	Quartzite breccia
	Overhang Jasp.	Plj	Jaspilite, limestone, shale
		Plt2	Metabasalt
	Mitakoodi Qtzite	Plt1	Feld. qtzite
	Argylla Formation	Pln	Rhyolite

Fig 2 LOCAL GEOLOGY CLONCURRY 3

(After Derrick et al., 1971)

Coring : BQ($1\frac{3}{8}$" diameter) coring from 14' to 79'4" (65'4")

Recovery : 34'2" - i.e., 52.5 percent

Drilling was slow and difficult, as the rocks were fractured, and tended to become wedged in the core barrel.

Results:

The core recovered consists of metadolerite, chlorite and amphibole schist, and sheared amphibolite, cut by narrow shear zones containing quartz and some secondary calcite; as the core was badly fractured, and its lithology monotonous, it was not logged in detail. The shearing is presumed to be due to faulting, possibly along the southwesterly extensions of a shear zone collinear with the northern part of Chinaman Creek (Fig. 2). This shear zone is marked at the surface by several large magnetite/haematite-rich bodies, and Lambourn & Shelley (1972) interpret the magnetic anomaly at the drill site as being due to a similar magnetite-rich body at depth. However, the drill hole did not reach such a body, and so the main objective of the hole was not attained.

BMR Cloncurry 4

Position: Lat. 20°51'40"S, long. 140°22'5", 22 km southwest of Cloncurry, 0.7 km east of the Malbon Road; Cloncurry 1:250 000 Sheet area (F/54-2), Marraba 1:100 000 Sheet area (6956). Access to the drill site is 1 km along a disused dirt track which parallels the Cloncurry-Mount Isa railway line. The dirt track branches off the Malbon Road on the south side of the railway crossing 20 km south of the Barkly Highway-Malbon Road intersection.

Local Geology:

The drill site is located in a geologically critical area between outcrops of Corella Formation and Marimo Slate (Fig. 3). Metasediments of both formations dip steeply to the southeast, but the nature of the contact between the two formations is unknown.

Objective:

To determine the nature of the contact between the Corella Formation and the Marimo Slate.

Drilling Details:

Direction and inclination	:	vertical
Date commenced	:	22 Sept. 1971
Date completed	:	1 Nov. 1971
Final Depth	:	255'
Coring	:	BQ ($1\frac{3}{8}$" diameter) coring from 49' to 255' (206')
Recovery	:	58'9" - i.e., 28.5 percent

Drilling was slow and difficult, as the rocks were foliated and intensely fractured, causing frequent wedging of the core in the core barrel.

Results:

The entire core was intensely fractured, and crumbled with little handling; as its lithology was monotonous, a detailed log was not made. It consisted of highly altered siltstone and shale, variably micaceous and kaolinitic, and deeply weathered. Some mylonitization and quartz veining was also present. The core represents a fault zone in micaceous siltstone and shale of the Marimo Slate. No information on the Corella Formation-Marimo Slate contact was obtained from this hole.

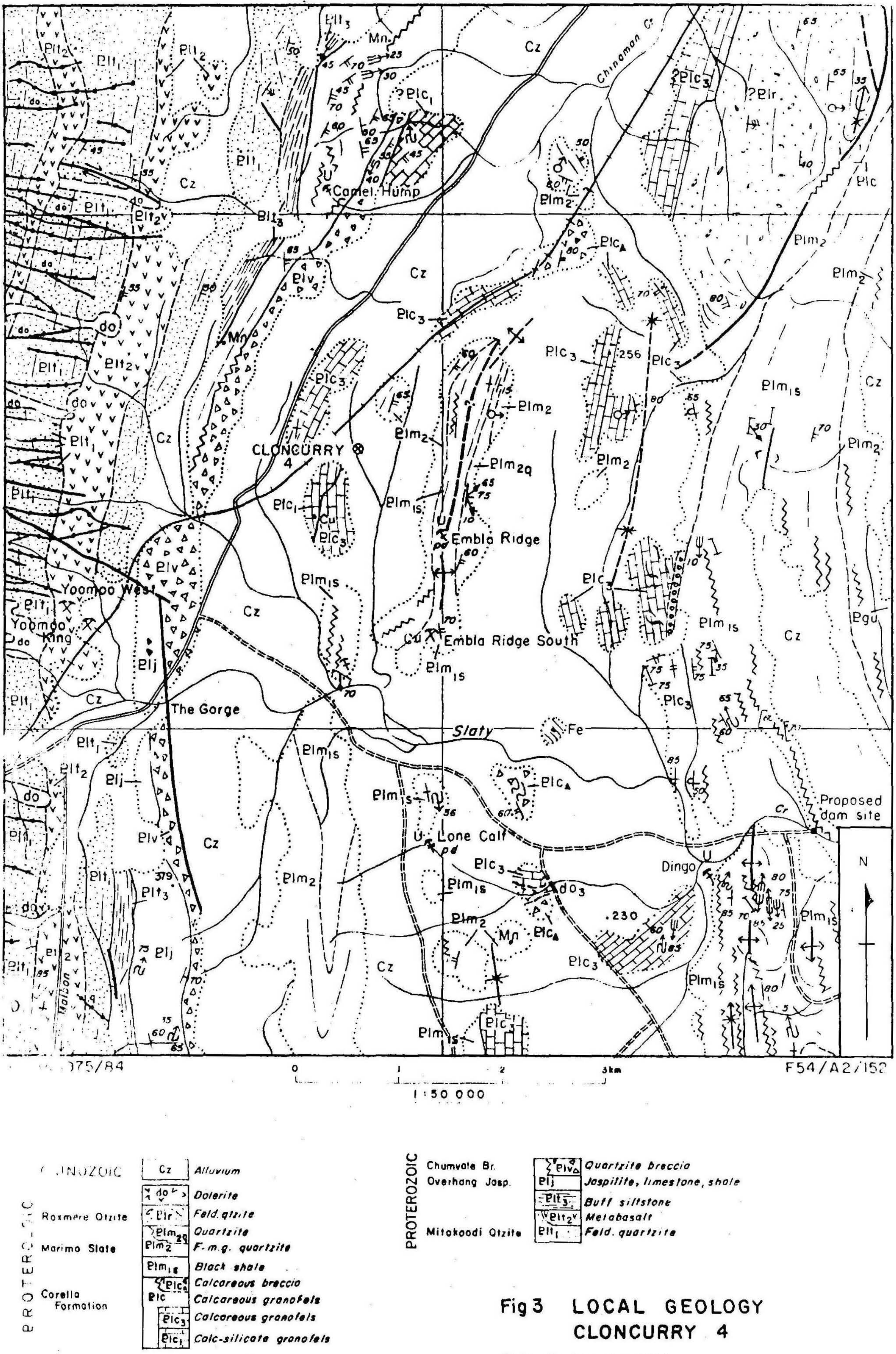


Fig 3 LOCAL GEOLOGY CLONCURRY 4

(After Derrick et al., 1971)

BMR Cloncurry 5

Position: Lat. 20°46'45"S, long. 139°52'50"E, 11 km west-northwest of Mary Kathleen township, 2 km north of the Barkly Highway; Cloncurry 1:250 000 Sheet area (F/54-2), Mary Kathleen 1:100 000 Sheet area (6856).

Local Geology:

Semidetailed regional geological mapping of the Mary Kathleen 1:100 000 Sheet area (Derrick et al., 1974) showed the presence of a sulphide-bearing black shale unit at the top of the uppermost member (Blc_3) of the Corella Formation (Fig. 4). The black shale unit is unconformably overlain by the Deighton Quartzite.

The area around BMR Cloncurry 5 has since been mapped in more detail, and minor changes have been made to the original mapping. The results of this mapping are shown in Fig. 4. The northern part of the area consists of part of a shallow north-plunging major syncline that contains Deighton Quartzite in its core. The syncline is faulted locally by a set of northeast-trending dextral strike-slip faults which represent splays from the Wonga Fault. Other minor north-northeast and north-northwest faults divide the area into several fault blocks.

The oldest rocks cropping out in the area of detailed mapping are ripple-marked feldspathic quartzite belonging to the middle member (Blc_2) of the Corella Formation. The quartzite is overlain by laminated calcareous siltstone and minor grey limestone of the uppermost member of the Corella Formation (Blc_3), which trends north-northwest and dips east at 45 to 60°. The siltstone containsabundant scapolite. The central part of the area is occupied by a black to dark grey carbonaceous shale of the Corella Formation (Blc_{3p}), which conformably overlies the laminated calcareous siltstone (Blc_3). This shale contains conformable lenses up to 50 mm long and 5 mm thick of pyrrhotite and pyrite, which have weathered to limonite near the surface. The shale has been broadly folded into basins and domes, and dips rarely exceed 40°.

Objectives:

(i) To determine the type and extent of mineralization

(ii) To obtain fresh core from a stratabound sulphide-bearing black shale zone for geochemical analysis

The results of the geochemical work are reported in Duff (in prep.).

Drilling Details:

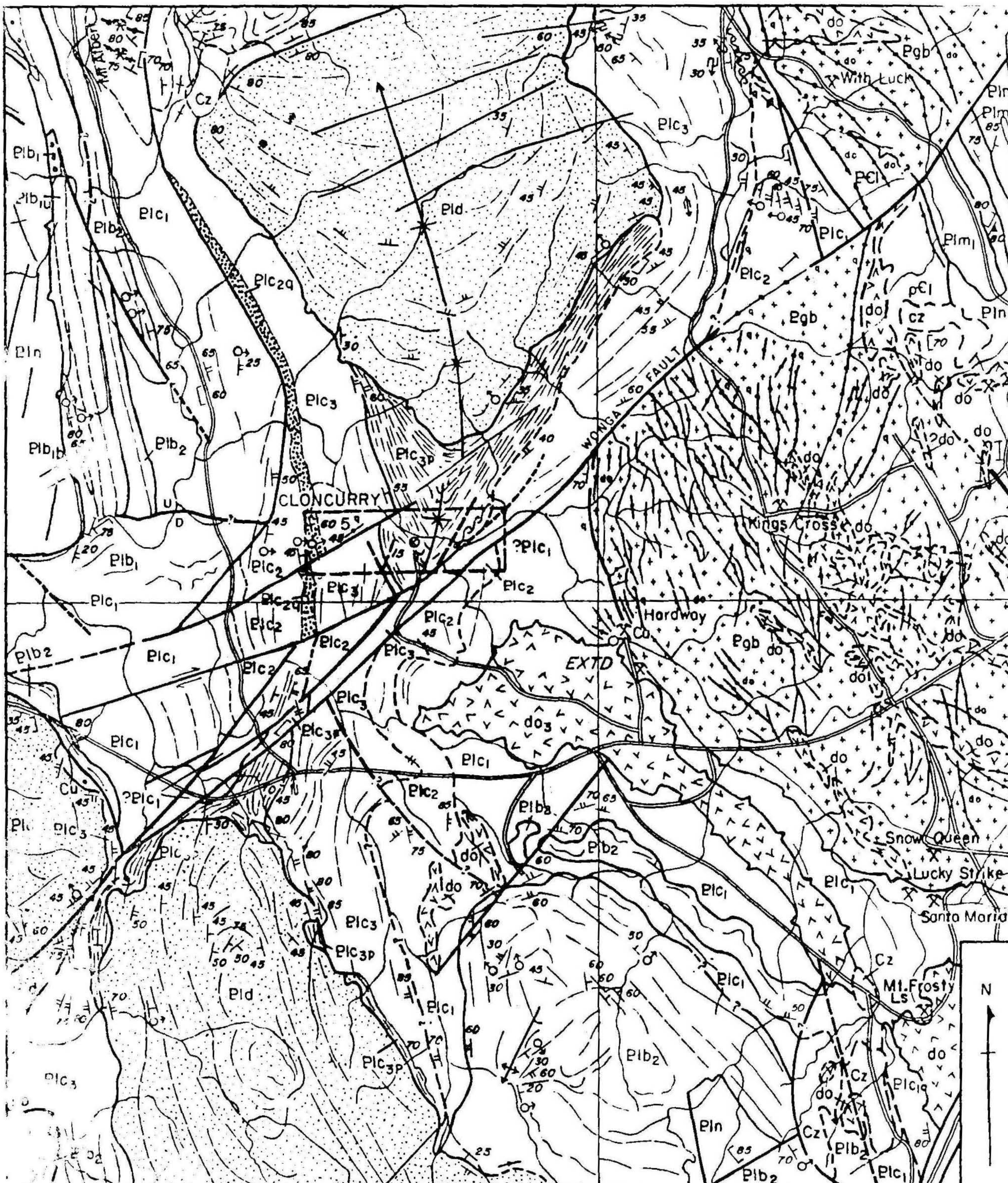
Direction and inclination	:	vertical
Date commenced	:	6 Oct. 1971
Date completed	:	29 Oct. 1971
Final Depth	:	180'6"
Coring	:	BQ (1⅜" diameter) coring from 19' to 180'6" (161'6")
Recovery	:	155' - i.e., 96 percent

Circulation was lost at 35' and at about 75', and cementing of the hole was necessary. The core recovered between 135' and 180'6" was lost in transit from the field to the Core and Cuttings Laboratory, Fyshwick, Canberra.

Description of Core (Figs 5 and 6):

(a) Mineralogy

The core consists of black carbonaceous shale with intercalations less than 10 mm thick of evaporitic minerals and sulphides. The upper part of the core is closely fractured, and joint and fracture surfaces are coated with gypsum and, in some places, pyrite.



CAINOZOIC		Cz	Alluvium
		do	Dolerite
PROTEROZOIC	Deighton Qtzite	Pld	Feld. quartzite
	King's Cross Gr.	Pgb	c.-m.g. granite
	Corella Formation	Plc3p	Black pyrrhotite
		Plc3	Calcareous granofels
		Plc2q	Feld. quartzite
		Plc2	Pelitic schist
		Plc1	Calcareous granofels
PROTEROZOIC	Ballara Qtzite	Plb2	Feld. quartzite
		Plb1b	Metabasalt
		Plb1	Arkose, conglomerate
	Argylla Formation	Pln	Acid volcanics
	Magna Lynn Bas.	Plml	Metabasalt
	Leichardt M'cs	p€l	Acid volcanics

(dashed box) Area of detailed Mapping

Fig. 4 Local Geology Cloncurry 5 (After Derrick et al., 1974)

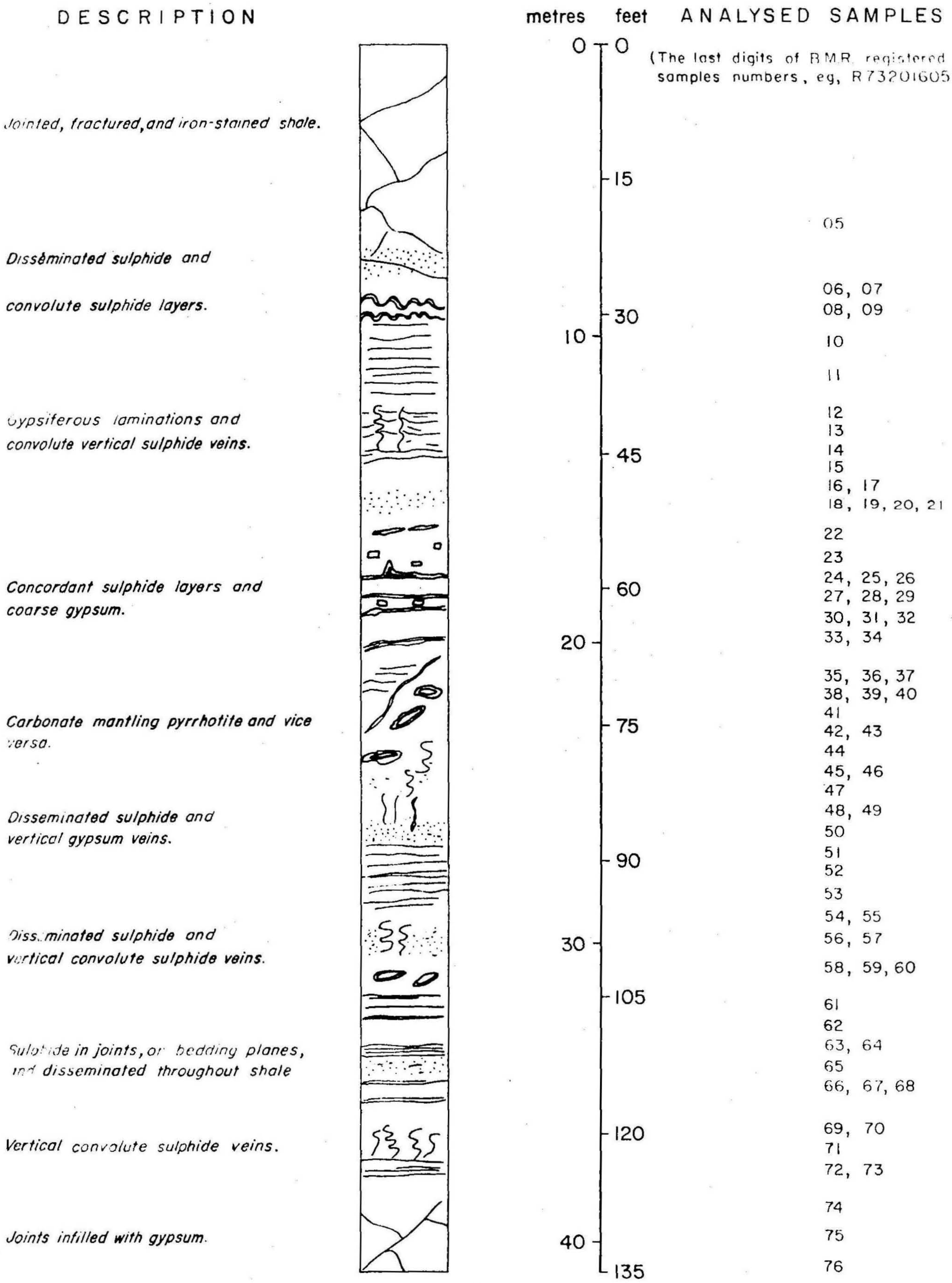
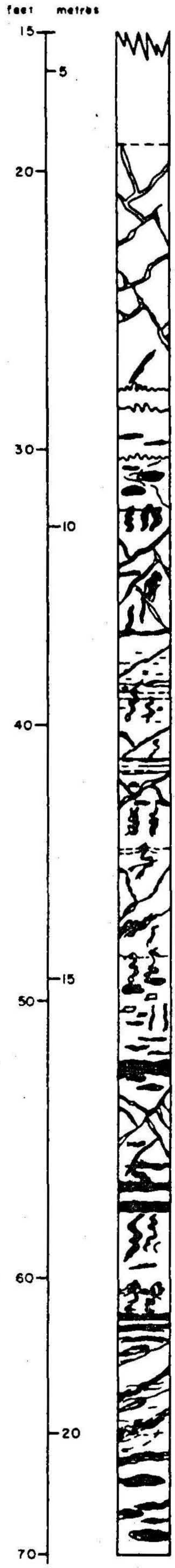


Fig. 5 Generalized log of the black shale, B.M.R. Cloncurry 5 showing positions and depths of analyzed samples. (See Duff, 1975)



Description	Sulphide
(Described features occur in black carbonaceous shale) Jointed, fractured, and iron-stained black shale.	
0'–19' Not recovered.	
Iron-stained, microfractured black shale Vertical calcite veins, fine gypsiferous lamination	Pyrite - discordant veins.
Jointed black shale, gypsum and limonite coating joints, minor quartz and gypsum veins.	
	Finely disseminated pyrite.
Tightly folded pyrite veins. Concordant folded pyrite lenses.	Pyrite in folded veins and lenses.
Contorted pyrite veins; concordant pyrite blebs mantled with gypsum.	Pyrite.
Numerous joints coated by gypsum and limonite.	
Concordant and near-vertical sulphide lenses.	Pyrite veins, lenses, joint fillings.
Disseminated pyrite.	
Folded near-vertical pyrite veins.	
Discordant pyrite veins.	
Concordant gypsum layering.	Pyrite-cracked and brecciated
Gypsum veins	
Folded pyrite veins mantled by gypsum	Minor chalcopyrite with pyrite.
Folded vertical veins and oblique sulphide veins	Pyrite.
Thin folded gypsum veins	
Gypsum crystals; near vertical sulphide veins.	Pyrrhotite and pyrite, minor sphalerite
Pyrrhotite blebs and layers.	
	Pyrrhotite
Joints coated with sulphides.	
Thick sulphide layers mantled by gypsum.	
Folded near-vertical pyrrhotite veins.	Pyrrhotite and minor chalcopyrite.
Near-vertical folded veins of pyrrhotite mantled by gypsum	Pyrrhotite
Vugs and veins of gypsum mantled by pyrrhotite.	
Veins and vugs of gypsum mantled by sulphide	Pyrrhotite and minor chalcopyrite
Lenses and veins of pyrrhotite and chalcopyrite mantled by gypsum	Pyrrhotite and minor sphalerite
Vugs of pyrrhotite mantled by gypsum.	

Fig. 6 A Detailed log of BMR Cloncurry 5

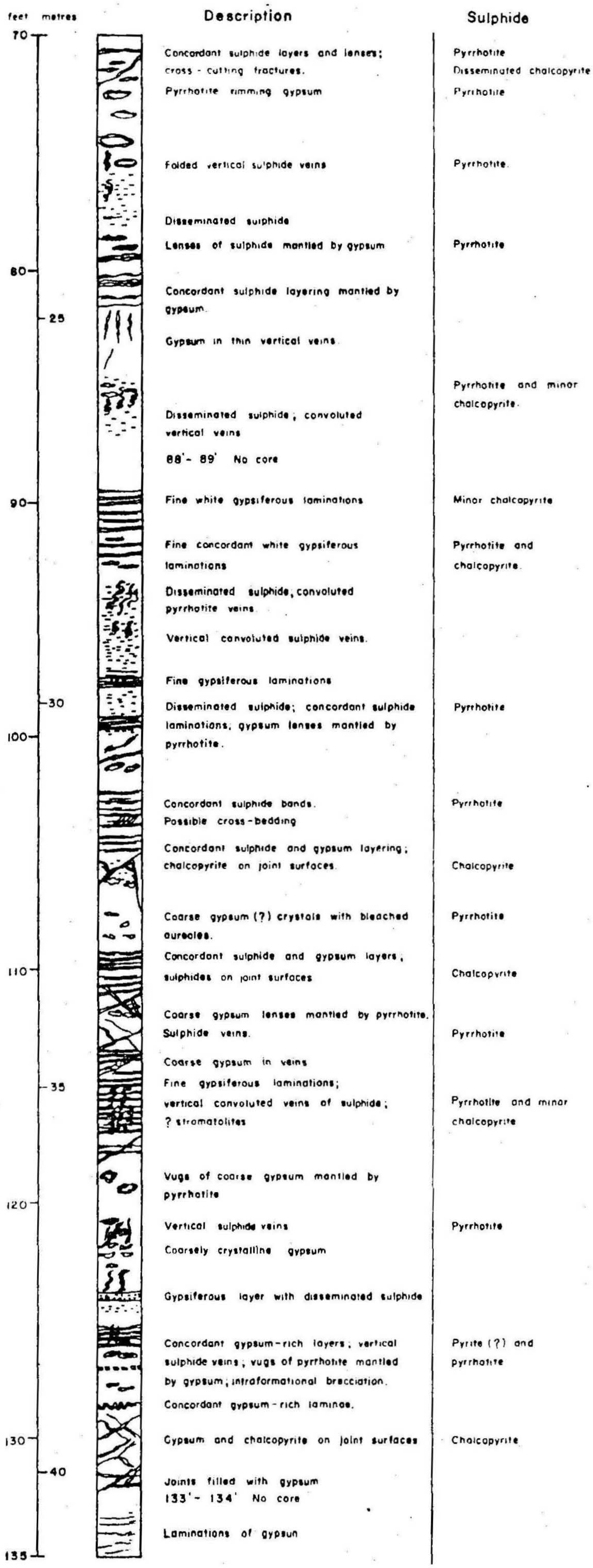


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Fig. 6 B Detailed log of BMR Cloncurry 5

Regional metamorphism of lower greenschist grade has converted the detrital component of the shale to a muscovite-biotite-alkali feldspar-quartz-chlorite assemblage, and has remobilized the evaporites, which have recrystallized to an anhydrite?-gypsum-calcite assemblage (X-ray powder photography suggests that a little anhydrite is present). Abundant organic carbon (1-5 percent of the shale) is distributed as thin discontinuous 'wisps' within the shale.

Muscovite and partly altered biotite form aggregates up to 0.8 mm across in the predominantly detrital parts of the shale. The biotite is characterized by light brown to gold pleochroism. Small grains of scapolite occur sporadically with calcite, mica, and quartz throughout the shale.

The principal opaque mineral is pyrrhotite, although toward the top of the core pyrite is more abundant. Minor chalcopyrite and sphalerite are associated with the pyrrhotite. Sulphide textures observed are:

(a) fine-grained disseminations

(b) coarse crystals in veinlets and blebs

(c) massive aggregates in concordant layers

(d) coatings on joints and fractures

The high pyrrhotite to pyrite ratio reflects a low to moderate grade of regional metamorphism (McDonald, 1967).

(b) Sedimentation Structures

Parallel lamination is enhanced by sulphide and evaporite layers. Small-scale cross-bedding is present at a few levels. Small domes, up to 4 cm high and 5 cm wide, may be stromatolitic structure (M.R. Walter, pers. comm., 1974) (Fig. 8), and the sulphide and evaporite layers may represent algal mats.

Soft-sediment deformation is reflected in the presence of thin intraformational breccia layers and by micro-recumbent folds with no attendant cleavage or decollement surfaces.

(c) Structures and Textures

The following features which disrupt the bedding recur throughout the core:

(i) Veinlets. These occur at all angles to the bedding, and range in thickness from 1 to 10 mm (Fig. 7). Where nearly vertical, they are invariably contorted. The veinlets consist of coarse quartz, mica, and pyrrhotite. Commonly the bedding of the shale has been displaced for a few millimetres along the veinlets. In other instances bedding has been domed rather than cut by a veinlet. Veinlets frequently appear to be discontinuous, but may be linked in an en echelon fashion by thicker veins parallel to bedding. Some are folded at one end only, indicating that some differential contortion has occurred.

(ii) Some pyrrhotite is concentrated in distinct layers and eye-shaped lenses which are generally concordant, although some are oblique to bedding, and range in length from a few millimetres to a few centimetres. A notable feature of some of these lenses and layers is the presence of a thin calcite mantle enveloping the pyrrhotite. Rarely, pyrrhotite envelopes a calcite core. The mantling is interpreted as a corona structure formed during metamorphism of the shale.

Discussion and Conclusions:

(a) Depositional Environment

The presence of stromatolites and the high carbon content indicate near-shore deposition. The abundance of gypsum, anhydrite?, and calcite in the shale, together with scapolite, a metamorphic phase which probably represents original halite (Ramsay & Davidson, 1970), indicates a hypersaline intertidal zone or a restricted lagoonal environment.

Fig. 7. Pyrrhotite mantled by calcite in concordant and contorted discordant veins in black shale from BMR Cloncurry 5, in the Upper Corella Formation. Natural scale.

Fig. 8. Possible stromatolite in black shale from BMR Cloncurry 5, in the Upper Corella Formation. Natural scale.

(b) <u>Sulphide Remobilization</u>

The sulphides were probably deposited in concordant layers, although subsequent mobilization has resulted in small-scale discordances. Recrystallization and grain growth may have occurred during diagenesis or metamorphism, and there are no clear criteria for distinguishing between a penecontemporaneous and tectonic origin for the veinlets. Differentially contorted veinlets represent vertical fractures in the shale which were filled with gypsum and calcite during diagenesis, and later contorted during differential compaction (see, for example, Conybeare & Crook, 1968; p.188). However, McDonald (1967) has suggested that originally stratiform sulphides can be locally modified during deformation and metamorphism by a process involving differential creep: the sulphide phases are more plastic than the rest of the shale, and separate physically. The veins may thus be related to a non-penetrative axial-plane fracture foliation, which is complicated by other diverse microstructures.

During the regional metamorphism to greenschist facies, remobilization resulted in the development of coarsely crystalline assemblages of quartz, muscovite, calcite, and pyrrhotite in the veins and lenses, and sulphide-calcite corona structures were formed by the concentration of previously disseminated sulphide. At the same time, concordant sulphide layering may have been enhanced by vertical migration of metal-rich solutions (Lambert & Bubela, 1970; Lambert, 1973).

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Appendix. Symbols used in Figures No. 2 – 3

- Formation boundary
- Intrusive boundary
- Unconformity
- Member or minor boundary
- Rock-soil boundary

. Most geological boundaries are accurate; boundaries are queried when approximate, inferred or concealed.

- Anticline, position accurate, with direction of plunge
- Anticline, position approximate, with direction of plunge
- Anticline, inferred
- Anticline, fold axis horizontal
- Syncline, position accurate, with direction of plunge
- Syncline, position approximate, with direction of plunge
- Syncline, position inferred
- Overturned anticline
- Overturned syncline
- Plunge of minor anticline
- Plunge of minor syncline
- Plunge of drag fold
- Plunge added to trend line
- Fault position accurate, showing relative horizontal movement
- Fault, position approximate
- Fault, inferred
- Fault, concealed
- Fault, inferred and concealed
- Normal fault, teeth on downthrown side, with dip of fault plane
- Lineament
- Fault breccia
- Shear zone
- Zone of silicification, with iron and manganese
- Bedding, measured strike and dip
- Bedding, measured strike and dip, facing unknown.
- Bedding, vertical
- Bedding, vertical, facing unknown
- Bedding, overturned
- Dip 45° (air-photo interpretation)
- Trend line
- Facing of beds
- Facing of lava flow
- Joint, measured dip
- Joint, vertical
- Joint, horizontal
- Joint pattern (air photo interpretation)
- Metamorphic foliation, dip measured
- Metamorphic foliation, vertical
- Cleavage, measured
- Cleavage, vertical
- Lineation on cleavage
- Lineation on bedding
- Lineation on bedding, facing unknown
- Lineation on metamorphic foliation
- Igneous banding, measured dip
- Igneous banding, vertical
- Current direction from cross-bedding

- Dyke or vein: do -dolerite, q -quartz, ap -aplite, py -quartz-feldspar porphyry, qf -quartzofeldspathic vein, quartz-feldspar pegmatite, lamp-biotite lamprophyre, Ls -limestone q-to - quartz tourmaline
- Bedded limestone, remobilised limestone

- Minor mineral occurrence
- Copper
- Manganese
- Limestone (calcite, marble)
- Gold
- Tourmaline
- Hematite
- Fluorite
- Iron
- Barytes
- Gemstones
- Amethyst
- Arsenic
- Molybdenum
- Ilmenite
- Chlorite
- Tremolite (Actinolite)
- Prospect
- Mine, with name
- Mine, not working
- Open cut, quarry
- Costean
- Treatment plant, not operating

- Bore, power-equipped
- Windmill
- Earth tank
- Dam on stream
- Waterhole
- Rockhole
- Waterfall on stream
- Lake

- Highway
- Road
- Vehicle track
- Railway line, with siding
- Airstrip
- Landing ground
- Homestead
- Yard
- Fence
- Township
- Telephone line
- Astronomical station
- Trigonometric station
- Spot height in metres
- Position doubtful

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