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Rum Jungle
Detailed Aeromagnetic Survey

Northern Territory, 1967

by

P. J. Browne - Cooper and R. A. Gerdes

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SUMMARY

A detailed aeromagnetic survey of an area of 200 square miles approximating the Hundred of Goyder was flown from May to July 1967.

The magnetic contour map derived from the survey shows a pattern of anomalies that correlates fairly well with the available geological information from surface mapping and drilling. The Giants Reef and Mount Fitch Faults are reflected in the magnetic contours and the trends of anomaly axes in general follow closely the strike of the sediments surrounding the Rum Jungle and Waterhouse Granite Complexes. Many of the individual anomalies can be explained by the known geology, but a number remain whose origin has not been established.

Localized anomalies in and along the margin of the Rum Jungle Complex are shown to be due to banded iron formations, but it is apparent that the major rock units into which the Complex has been subdivided on geological evidence do not have sufficient susceptibility contrasts to admit of their differentiation by the aeromagnetic method.

There appears to be no direct relation between the magnetic anomalies and occurrences of economic mineralization.

1. INTRODUCTION

A detailed aeromagnetic survey was flown in the Rum Jungle area, Northern Territory, from May to July 1967. The area, approximately coincident with the Hundred of Goyder, was flown on lines one tenth of a mile apart and oriented east-west (Plate 1).

Lead and copper mineralization had been known at Rum Jungle for many years, and in 1907 a few shallow pits, known as the Rum Jungle Copper Mines, were excavated. Uranium was discovered in 1949, and between 1953 and 1963, several uranium orebodies were mined by Territory Enterprises Pty Ltd (TEP) on behalf of the Australian Atomic Energy Commission. In addition to uranium, significant quantities of copper and lead have been produced. Since 1963, mining in the area has been limited; the Intermediate Copper orebody was mined from 1964 to 1965 and a shaft was put down on Browns lead prospect in 1969. Processing of stockpiled uranium ore and extraction of copper from tailings by leaching is being continued.

Since 1949, a large amount of geological, geochemical, and geophysical work has been done in the area to assist the search for uranium and base metals. Previous magnetic surveying included an airborne survey by the Bureau in 1953 with a DC3 aircraft (Daly, 1957), and in several localities ground magnetic surveys have been used to supplement investigations by other geophysical methods.

2. GEOLOGY

The following notes on the geology of the survey area (Plate 2), which lies on the western margin of the Pine Creek Geosyncline, are adapted mainly from Spratt (1965).

Sedimentary Rocks

Lower Proterozoic

The oldest sedimentary rocks of the area are the Batchelor, Goodparla and Finniss River Groups, all of Lower Proterozoic age.

Batchelor Group

The Beestons Formation consists chiefly of arkose with minor quartzite, slate, grit, and conglomerate. It crops out discontinuously along the southern edge of the Rum Jungle Granite. Thickness is about 1000 feet.

The Celia Dolomite consists of silicified dolomite, dolomite, and dolomitic breccia, and crops out on the southern edge of the Rum Jungle Granite or overlying the Beestons Formation. Thickness is about 1000 feet.

The Crater Formation consists of clastic sediments including greywacke, sandstone, quartzite, and conglomerate, about 2500 feet thick. Most beds are markedly lenticular. The Hematite Boulder Conglomerate bed, up to 100 feet thick, consists of angular and rounded pebbles and boulders of quartz and banded ironstone in a hematitic matrix. It has proved useful as a marker horizon in the Hundred of Goyder. The Crater Formation is continuously present around both the Rum Jungle and the Waterhouse Granite Complexes, and immediately overlies them for much of its length. Some quartz-tourmaline veins have invaded the Formation near the margins of the Complexes.

The Coomalie Dolomite consists of dolomite, dolomitic marl, and minor siltstone. The dolomite has little outcrop, but where it is exposed it may be a hematitic marble, a highly silicified rock, or a sandy friable rock. Some areas are covered with thick laterite. Thickness is of the order of 2000 feet.

Goodparla Group

The Golden Dyke Formation is a sequence of argillaceous sediments, varying both laterally and vertically, comprising graphitic, sericitic, and chloritic slates and siltstones. Minor lenses of dolomite occur in the Formation and quartz and calcite veining is common. The formation is about 6000 feet thick. Amphibolites occur in the Golden Dyke Formation. Rhodes (1965) considers that they probably represent tholeiitic dolerite sills which were emplaced in the sediments before folding and metamorphism.

The Acacia Gap Tongue consists of a wedge of grey pyritic quartzite with its thin edge to the south, where it interfingers with the Golden Dyke Formation.

Finniss River Group

The Burrell Creek Formation, consisting of slate, siltstone, and greywacke, crops out in the extreme western part of the survey area.

Upper Proterozoic

Tolmer Group

The Depot Creek Sandstone Member of the Buldiva Sandstone crops out in the Embayment area, and in an area running from north of the Rum Jungle Creek mine to the Castlemaine Hill prospect. It consists of a quartz sandstone with lenses of hematite-rich calcarenite breccia and lenses of quartz pebble conglomerate.

Unclassified

The hematite-quartz breccia consists of angular fragments of quartz in a pink sandy matrix up to 500 feet thick. In places, the quartz fragments are absent and the rock is a pink quartzite. Beds of siltstone, mudstone, and chlorite schist occur in the unit in subordinate amounts. In the Rum Jungle area this rock invariably overlies the Coomalie Dolomite.

Igneous Rocks

The igneous rocks of the area consist of two granitic masses, the Rum Jungle and Waterhouse Complexes, and several dolerite sills. The Rum Jungle Complex consists of schists and gneisses, granite gneiss, diorite, granite, pegmatite, quartz-tourmaline veins, and dolerite dykes, of which only the last two are younger than the surrounding sediments (Ivanac & Walpole, 1963). The Waterhouse Complex has not been studied to the same extent, but is apparently similar.

Several dolerite sills occur in the Golden Dyke Formation and at least one in the Crater Formation.

Structure

The Lower Proterozoic sediments have a regional north-south strike and have been folded along north-south axes into broad domes and low-amplitude synclines and anticlines. The two granites occupy the cores of domes. Two later periods of movement have been established, the second of which formed the Giants Reef Fault, which strikes northeast through the Rum Jungle Complex and the surrounding sediments. The fault has been traced on air-photographs for over 50 miles; the youngest rocks cut by the fault are of Upper Proterozoic age. In the Rum Jungle area, quartz reefs mark much of the fault line in the granite, but in the sediments there is no obvious surface expression. Horizontal displacement measured in the Hematite Boulder Conglomerate is 3.5 miles, north side east.

The movement caused considerable distortion in the surrounding rocks, particularly on the north side, where the sediments have been dragged into a highly folded and strongly faulted block, known as the Embayment. The overall structure of the Embayment area is synclinal with a pitch to the west, but local pitch reversals occur.

The Mount Fitch Fault is a north-trending fault in the west of the survey area. At the Mount Fitch prospect, mining and drilling have shown the movement on the fault to be west block down. Elsewhere the fault is not well exposed and its position is largely inferred.

Mineralization

Mining in the Rum Jungle area has been mainly for uranium, although considerable quantities of copper have also been produced. Four main uranium orebodies have been mined - Whites, Dysons, Rum Jungle Creek South, and Mount Burton. A large medium to low grade body of lead mineralization has been proved at Browns Prospect and a copper deposit has been mined at the Intermediate mine between Browns and Whites. In 1966 a zone of lead-zinc-silver mineralization was discovered at the Woodcutters L5 prospect in the Rum Jungle East area (Crohn, Langron, & Prichard, 1967). The uranium and base metal occurrences all lie within the Golden Dyke Formation and commonly close to its contact with the underlying Coomalie Dolomite. Deposits of phosphate rock occur in the Castlemaine Hill area.

3. RESULTS AND INTERPRETATION

The aeromagnetic contours for the survey area are shown superimposed on the geological map in Plate 2.

The plate shows the qualitative geophysical interpretation which comprises the delineation of positive and negative trends and inferred faults, and the zoning of the Rum Jungle Complex. Numbered magnetic anomalies are those which have been analysed or are referred to in the text. Profiles used in the analysis of the anomalies were constructed from the contours. Many anomalies are not amenable to satisfactory analysis because of irregularity of shape or interference from adjacent anomalies.

Several different methods of analysis were used, depending on the assumed shape of the anomaly source. Circular anomalies with a pronounced minimum south of the maximum were assumed to be due to spherical bodies and were analysed by the method of Daly (1957). Elongated anomalies were assumed to be due to tabular bodies and were analysed by the method of Gay (1963) by constructing profiles from the contours, normal to the long axis of the anomaly (i.e. the assumed strike direction). Preliminary depths to bodies were usually found by applying the method of Peters (1949) to the profiles. Where curve-fitting was not satisfactory the method of Moo (1965) was sometimes used with success. Table 1 gives a summary of the results of analyses of anomalies together with an indication of the methods used in each case.

The magnetic contour map of the survey area is similar to that derived from the DC3 aeromagnetic survey of 1953, although a more complex pattern is evident from the additional data now available. The magnetic results have been examined in relation to the surface geology, which has been mapped in some detail, and to the subsurface information obtained from drilling. The broad pattern of magnetic anomalies correlates fairly well with the known geology. The disposition of anomalous zones over the sediments follows the trend of the sediments around the Rum Jungle and Waterhouse Complexes. Many of the individual anomalies can be explained by the known geology, although there remain a number of magnetic features whose origin is unknown or can only be tentatively inferred.

In the western part of the survey, there is an abrupt change from the undisturbed area on the west to the disturbed area on the east, marking a well-defined magnetic boundary which corresponds closely with the Mount Fitch Fault shown in Plate 2. No evidence was found to support the existence of this fault in the geological mapping carried out in 1964 by Dodson & Shatwell (1965) in the Rum Jungle Triangle area (which extends southwards from Mount Burton). However, the magnetic contours strongly suggest the existence of a fault in this area and its continuation northwards; but they also suggest that near Mount Fitch the fault diverges to the west from the inferred position shown on the geological map. Anomalies 1 and 2 (north-northwest of Mount Fitch) appear to lie on a continuation of the strongly disturbed zone south of Mount Fitch and indicate that the Golden Dyke Formation probably extends farther west than the previously accepted boundary.

The Giants Reef Fault is less evident in the magnetic contours than the Mount Fitch Fault. In places it is reflected in the abrupt termination of anomalies or changes in strike of the contours. Evidence of the fault is apparent near the northern survey boundary in the form of a steep magnetic gradient where the Acacia Gap Tongue abuts the Rum Jungle Complex.

Many strong anomalies occur in the Rum Jungle Triangle and Embayment areas. Most of these had been revealed previously by ground surveys (Ashley, 1966; Daly, Horvath, & Tate, 1962), but the detailed airborne survey provides a more complete coverage of this disturbed area.

Information on the cause of the anomalies is available from drilling carried by BMR and TEP in the area between Mount Fitch and Dolerite Ridge. Seven holes were drilled by BMR in 1964 to test geophysical and geochemical anomalies (Prichard, 1964). Four of these, located on or close to Anomaly 3, intersected amphibolite carrying pyrite and pyrrhotite. DDH 64-4, a vertical hole near the centre of the anomaly, penetrated amphibolite from the base of the alluvium to the full depth of 325 ft. Pyrrhotite was more common than pyrite, and the two minerals made up more than 10% of the amphibolite. These results have established the cause of the anomaly as pyrrhotite within the amphibolite.

Several holes have been drilled on the flanks of Anomaly 4, mainly west, northwest, and south of the centre of the anomaly. The holes intersected Golden Dyke sediments containing pyrrhotite and pyrite. Dolerite and amphibolite were also intersected. The anomaly could be due to pyrrhotite or dolerite or both.

Dolerite occurs near the centre of Anomaly 5 and amphibolite on the western flank, and pyrrhotite in amphibolite or dolerite could account for the anomaly. The complex pattern of anomalies immediately south of Anomaly 5 is probably also related to amphibolite, which is known to occur here in the Golden Dyke Formation.

In the Dolerite Ridge area, three holes drilled near the centre of Anomaly 8 intersected pyritic black slate but did not reveal the cause of the anomaly. This is perhaps understandable, as the maximum depth of drilling was 350 feet compared with the estimated depth of 750 feet for the source of the anomaly. However, two drill holes, about 1/3 mile south of the anomaly centre encountered calcareous amphibolite with a high content of pyrite and pyrrhotite (up to 40% by volume). The pyrrhotite in this amphibolite appears to be the most probable cause of the anomaly. It is doubtful whether the dolerite in this area affects the anomaly appreciably, as the anomaly maximum occurs about 2000 feet east of the dolerite outcrop.

Anomaly 9, southwest of Browns deposit, was covered by previous ground magnetic surveys described by Daly, Horvath, & Tate (1962). The axis of the anomaly is roughly parallel to the strike of the orebody, but the two are apparently not directly related. Drilling revealed a large mass of amphibolite on the southeast side of the orebody. It was concluded that the magnetic anomaly was caused by the pyrrhotite content of the amphibolite. The ground magnetic work indicated a variation in the magnetic susceptibility of the amphibolite. In other parts of the Rum Jungle area, the aeromagnetic results also show similar evidence of a considerable variation in the magnetic properties of the rocks described as 'amphibolites'.

A steep magnetic gradient extending from the Giants Reef Fault south of Browns deposit to the Mount Fitch Fault has been interpreted as an east-striking fault separating the highly anomalous area to the north from the moderately disturbed area to the south.

Anomalies 10 and 11 occur over Golden Dyke Formation in which drilling has shown amphibolite with pyrite and pyrrhotite to be present. The anomalies are attributed to pyrrhotite in the amphibolite.

Anomaly 14 was delineated by a previous ground survey (Ashley, 1966) and shown to occur over a bed of hematite boulder conglomerate at the top of the Crater Formation. Hand specimens of the conglomerate from this area were found to be noticeably magnetic, presumably owing to magnetite, although magnetite could not be separated from a crushed sample of the rock (Dodson & Shatwell, 1965). The width of the conglomerate outcrop is only 5 to 10 feet, but from the analysis of the ground magnetic data it was concluded that the conglomerate must thicken with depth. This conclusion is supported by the aeromagnetic results, which suggest that the source of the anomaly is at a depth of 250 feet and has a width of several hundred feet. Anomalies 12 and 13 are also attributed to the hematite boulder conglomerate as they coincide with the mapped continuation of the conglomerate bed to the northeast. Their sources are estimated to be at or close to the surface.

In the north of the Embayment area, Anomaly 6 and the group of three small anomalies, 7, occur over Crater Formation close to the contact with the Rum Jungle Complex. A previous ground magnetic traverse by Ashley (1966) crossed the axis of 7 and the anomaly was attributed to magnetic portions of the hematite boulder conglomerate. The airborne anomalies 6 and 7 confirm this interpretation as they coincide with the mapped position of the conglomerate outcrop. The effect of the fault which has displaced parts of the Crater Formation is evident in the magnetic contours.

Anomaly 15 lies on the east side of and close to the Giants Reef Fault and its axis is parallel to the fault. Following the airborne survey a ground magnetic traverse was surveyed over this anomaly in 1968 by Gardener (personal communication). The peak of the anomaly was found to be 400 feet east of the Fault as shown in recent geological mapping. The area is a black soil flat without outcrop. The anomaly was auger drilled in 1969 and shown to be caused by amphibolite. Anomaly 9, southwest of Browns deposit, is also due to amphibolite, and it is interesting to note that anomalies 15 and 9 are on opposite sides of the Giants Reef Fault and the distance between them is approximately the same as the displacement of the fault (Gardener, personal communication).

In the southwest corner of the survey area, a series of anomalies, 17, 19, 20, and 21, follow the strike of the Crater Formation, which crops out around the margin of the Waterhouse Complex. Hematite boulder conglomerate is known to occur near Anomaly 19 and may be the cause of all these anomalies. However, this explanation is difficult to reconcile with the analysis of the anomalies which, if tabular bodies are assumed, suggests that the bodies are dipping steeply towards the Waterhouse Complex.

The magnetic contours show a relative displacement between the axes of Anomalies 20 and 21, and a negative magnetic lineation striking east and separating the two anomalies. A fault is suggested and its existence is supported by the apparent offset of the Crater and Beestons Formations in this locality.

A distinct gradient extends northeast from Anomaly 18 for about 2½ miles and is interpreted as marking the boundary, perhaps in the form of a fault, between the Waterhouse Complex and the Crater Formation.

Anomaly 23 is on outcropping Waterhouse Granite and 22 is north of the outcrop but on alluvium probably underlain by Waterhouse Granite. Analysis of the anomalies by the method of Moo (1965), assuming tabular bodies, gives depths of 350 feet and 100 feet, and dips of 45°S and 25°SSE respectively. In the absence of detailed geological mapping of the Waterhouse Granite, it is difficult to assign a cause to these anomalies.

A zone of low magnetic relief extends southeast from Rum Jungle Siding through the Castlemaine Hill area to the southern boundary of the survey area, thence east to the southern end of the Gould airfield, and north from this point to the Batchelor road. Outcrop in the zone consists of Depot Creek Sandstone to the northwest and scattered outcrops of Coomalie Dolomite and Golden Dyke Formation. The low magnetic relief suggests that Coomalie Dolomite underlies much of the zone.

In the Rum Jungle Creek South area, slates and schists of the Golden Dyke Formation attain a thickness of several hundred feet in the deepest part of the syncline between the Waterhouse and Rum Jungle Complexes. (Berkman, 1968). A few hundred feet west of the Rum Jungle Creek South opencut, a drill hole intersected more than 900 feet of what has been logged as amphibolite, including both igneous and sedimentary amphibolite (Bryan, 1962). There are flexures of the magnetic contours in this area, but neither the amphibolite nor other rocks of the Golden Dyke Formation appear to produce appreciable magnetic effects.

Tme small circular anomaly, No. 24, near the Laterites prospect, has been analysed assuming a spherical source. The anomaly arises from a shallow depth and is probably due to the ferruginized sediments which here overlie the Coomalie Dolomite.

North of Crater Hill, anomalies 25 and 26 appear from the geological map (Pl. 2) to occur over Celia Dolomite near its contact with Beestons Formation. In order to investigate these anomalies further, ground magnetic traverses were surveyed subsequently (Gardener, personal communication). Anomaly 25 was found to be due to an ironstone outcrop, and another ironstone outcrop was observed to be the cause of the secondary magnetic peak about 1/4 mile southeast of anomaly 25. No ferruginous material was found at anomaly 26. The anomaly may be due to ironstone buried under soil and debris. The ironstone outcrops appear similar to known outcrops within the Rum Jungle Complex. The outcrop between anomalies 25 and 26, previously mapped as Celia Dolomite, was found to include arkose and conglomerate and is now considered to be Beestons Formation. The ironstone outcrops may be part of the underlying Rum Jungle Complex.

Farther to the east, anomalies 27 and 28 occur over the Crater Formation. Analysis of the anomalies suggests they are due to shallow bodies dipping to the south. Ground magnetic traverses surveyed in 1969 showed that the anomalies are due to the hematite boulder conglomerate at the base of the Crater Formation. The conglomerate was found to be magnetic and he anomalies occur where the conglomerate is abnormally thick. (Gardener, personal communication).

The eastern margin of the Rum Jungle Complex immediately south of the Giants Reef Fault is marked by a line of three anomalies, 30, 31, and 32. Subsequent to the airborne survey, gravity and ground magnetic traverses were surveyed in an area which includes anomalies 31 and 32 (Williams, 1970). These two anomalies were confirmed on the ground and were found to coincide with outcrops of banded iron formation. Anomalies 30, 31, and 32, and also 29 farther to the south, are attributed to banded iron formation. Between anomaly 31 and the Giants Reef Fault, an amphibolite body was delineated by the gravity survey and confirmed by auger drilling. The magnetic data show this amphibolite to be practically non-magnetic.

In the northeastern part of the survey area, strong anomalies 33 and 34 coincide with an outcrop of Acacia Gap Tongue. Anomaly 33 has an amplitude of about 400 gammas. Analysis assuming a tabular body indicates a depth of 650 feet, a width of about 1200 feet and a dip of 60° to the east. A somewhat greater depth and a dip to the southeast was estimated for anomaly 34. Both anomalies indicate a fairly high magnetic susceptibility for the Acacia Gap Tongue, suggesting appreciable magnetite or pyrrhotite content. The offset between the axes of the anomalies confirms the existence of a fault as shown on the geological map.

A zone of moderately intense anomalies occurs immediately east of and parallel to the Acacia Gap Tongue outcrop, and extends farther south into an area mapped as Golden Dyke Formation. These anomalies coincide with a band of non-outcropping amphibolites revealed by auger drilling (Semple, 1968). The amphibolite is thought to be not of igneous origin but 'rather a metamorphosed calcareous bed in the Golden Dyke Formation'.

South of the Acacia Gap Tongue outcrop, anomalies 35, 36, and 37 occur over the Golden Dyke Formation and form a disturbed zone which closely follows the contact between Golden Dyke and Coomalie Dolomite. Geochemical anomalies detected in this area (Semple, 1968; Willis, 1969) fall in a zone broadly similar to that of the magnetic anomalies. Diamond drill holes to test the geochemical anomalies were not in positions suitable specifically for testing the magnetic anomalies and the causes of magnetic anomalies 35, 36, and 37 have not been established.

The Woodcutters area from L3 to south of the L5 prospect shows little magnetic relief. Structurally the area is an anticline. A relatively thin section of Golden Dyke rocks overlying the Coomalie Dolomite has been inferred from drilling information and the results of electromagnetic (Slingram) surveys (Crohn, Langron, & Prichard, 1967). The proximity of the Coomalie Dolomite to the surface would explain the absence of magnetic anomalies.

East of the Stuart Highway, in the north of the survey area, an anomalous zone coincides with outcrops of the Acacia Gap Tongue. The zone continues south and swings west through Area 65. South of the Coomalie Airfield, the sources of anomalies appear to occur in both Golden Dyke and Acacia Gap rocks. However, the Acacia Gap Tongue is shown to be variable in its magnetic response, and where it crops out from near Coomalie Creek to south of Mount Deane, it causes little magnetic disturbance.

The circular anomaly in Area 65 was previously investigated by a ground magnetic survey (Douglas, 1962), with traverses at 100-foot spacing. Two main anomalies and several smaller ones were indicated. Douglas attributed the main anomalies to amphibolite and the smaller ones to either separate bodies of amphibolite or small magnetic portions in a large mass of weakly magnetic amphibolite. TEP drilled eight diamond drill holes in Area 65 to test radiometric and electromagnetic anomalies (Spratt, 1962), but the magnetic anomalies which lie in the southwestern part of the area were not drilled and the source of the anomalies has not been confirmed.

A high magnetic axis or ridge of about 300 gammas average amplitude extends from Area 65 to anomaly 39, following the mapped outcrops of Golden Dyke and Acacia Gap Tongue. The ridge appears to be offset to the south and to continue through anomalies 41 and 42, indicating a possible fault striking north.

In the southeastern corner of the survey area, two curved positive axes follow the folding of the Burrell Creek Formation. Anomalies 43, 44, 45, and 46 have been analysed, but estimated dips are shallower than the measured dips of the bedding in this area. Depths to the causative magnetic bodies range from 50 feet to 250 feet and susceptibility is of the order of 2.5×10^{-3} cgs. Anomalies 43 and 46 occur near the contact of the Burrell Creek with the Golden Dyke Formation. Anomalies 44 and 45 occur over Burrell Creek Formation. Elsewhere this Formation appears to be generally non-magnetic. The causes of these anomalies are not known.

Over the Rum Jungle Complex, there appears to be little correlation between the magnetic results and the major rock units into which the Complex has been subdivided by Rhodes (1965). Two zones of low magnetic disturbance are marked on the interpretation map. The northern one corresponds closely with the arcuate belt of granite gneiss mapped by Rhodes. The southern zone is mainly occupied by coarse granite, large feldspar granite, and leucocratic granite.

Several small isolated anomalies, such as 48 and 49, occur in the Complex. Anomaly 49 is attributed to banded ironstone which crops out at the anomaly, and the nearby anomalies are probably also caused by banded ironstone. Similar anomalies due to banded ironstone along the eastern margin of the Complex have already been noted.

CONCLUSIONS

The magnetic contour pattern obtained from the survey shows good agreement with the structural geology of the area. In general, the trends of the anomalies parallel the strike of the sediments surrounding the Rum Jungle and Waterhouse Complexes. The major known faults are reflected in the magnetic data and additional faults not shown by the surface geology have been inferred from the data. However detailed comparison of anomalies with known geology shows that the correlation between the magnetic results and the mapped formations is by no means consistent.

The Coomalie Dolomite is shown to be non-magnetic and the Burrell Creek Formation, except possibly in the southeastern corner of the survey area, is generally weakly or non-magnetic. The Acacia Gap Tongue, where it outcrops in the northeast of the area, both east and west of the Stuart Highway is strongly magnetic, but some outcrops, e.g. southwest of Coomalie Airfield, have no associated anomalies. Strong anomalies occur over parts of the Crater Formation and have been attributed to a bed of hematite boulder conglomerate, but in many places the Crater Formation causes no appreciable anomalies.

The strong anomalies in the Rum Jungle Triangle and Embayment areas are due mainly to the pyrrhotite content of the amphibolites occuring in the Golden Dyke Formation. Much weaker anomalies arise from known amphibolites in the area east of the Complex and in places, e.g. in the Rum Jungle Creek South area, amphibolites give no appreciable magnetic effects. The results confirm conclusions from previous work that the rocks included under the field term of amphibolites are variable in composition. The anomalies over the Golden Dye Formation east of the Gould Airfield are tentatively attributed to amphibolites.

Attempts to subdivide the Rum Jungle Complex into zones on the basis of the magnetic data have been only partly successful. It is apparent that the major rock units of the Complex described by Rhodes (1965) do not have sufficient susceptibility contrasts to allow their differentiation by the aero-magnetic method. The most prominent magnetic features in the Complex are the localized anomalies due to banded iron formations.

Examination of the survey results has not shown any direct relationship between the magnetic anomalies and economic mineralization. The known orebodies do not coincide with magnetic anomalies, and some, such as the Rum Jungle Creek South and Woodcutters orebodies, are in areas of particularly low magnetic relief.

A number of anomalies, such as 15, which parallels the Giants Reef Fault in the west of the area, 35, 36, and 37 in the Rum Jungle East area, and the anomalies in the southeast, have not been satisfactorily explained and further investigation of these would be of interest. However, drilling of these anomalies could not be justified on economic grounds, unless supporting evidence for possible mineralization could be provided by geological or geochemical work or other geophysical methods.

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APPENDIX I

Operational Details

STAFF

BMR:	P.J. Browne-Cooper	:	Party Leader
	R.A. Gerdes	:	Geophysicist
	W.R.D. Buckley	:	Drafting Officer 27th April to 31st May
	L.M. O'Toole	:	Drafting Officer from 30th May
	P. Evans	:	Senior Technician (radio)
	B.M. Tregellas	:	Geophysical Assistant
	P.S. Moffat	:	Drafting Assistant
TAA	First Officer G.E. Brown	:	Pilot

EQUIPMENT

Aircraft	:	Cessna 180, VH-GEO
Magnetometers	:	MNS-1 (prototype) proton precession with towed bird detector, output to two Moseley Autograf recorders. MNS-1 proton precession, base station monitor, output to Esterline Angus recorder.
Radio Altimeter	:	AN/APN-1
Camera	:	Modified Vinten, 35mm single frame with wide angle lens.

SURVEY SPECIFICATIONS

Altitude	:	Aircraft nominally 280 ft above ground level with detector at 250 ft above ground level.
Line Spacing	:	Nominally one-tenth mile.

Line Direction	:	East-west
Recorder Sensitivities	:	Moseley recorders- 100 and 1,000 gammas f.s.d. Esterline Angus recorder- 100 gammas f.s.d.

OPERATIONS

Survey Party arrived Batchelor	27th April
Flying commenced	16th May
Flying concluded	30th June
Survey party departed for Canberra	26th July

DIURNAL VARIATION

The effects of the diurnal variation of the Earths magnetic field were removed from the survey records by the flying of a baseline before and after each flight. The baseline was chosen for its ease of reflying and low magnetic relief. The correction was made assuming a linear variation of the magnetic field between the times when the baselines were flown.

APPENDIX II

Volumetric Susceptibility of Crushed Samples, using the SHARPE SM-4 Magnetic Susceptibility Meter

The volumetric susceptibilities of crushed surface samples collected during the survey are tabulated in Table 2.

The volume susceptibility of the Batchelor and Goodparla Groups and Buldiva Sandstone ranged from 12 to 53 x 10^{-6} cgs units, and fall within the generally accepted range of values for sandstone and siltstones.

The arkose and siltstone of the Beestone Formation (Batchelor Group) collected at 13°1½'S and 131°2½'E gave volumetric susceptibilities ranging from 9.9 to 22.2 x 10^{-6} cgs units, the mean being 16.0 x 10^{-6} cgs units. These values are as expected for such sediments. A banded quartz ironstone from an outcrop of Beestone Formation situated at 12°56¾'S and 131°4½'E, had a volume susceptibility of 1001 x 10^{-6} cgs units, i.e. 100 times higher than the other values obtained for this Group.

An amphibolite dyke situated in the Golden Dyke Formation gave a low volumetric susceptibility of 34.7 x 10^{-6} cgs units. The tourmalinized granite and biotite granite of the Rum Jungle Granite Complex showed the same low volumetric susceptibility i.e. 32.2 x 10^{-6} cgs units.

TABLE 1

RESULTS OF ANALYSES OF INDIVIDUAL ANOMALIES

Anomaly No.	Amplitude gammas	Depth ft bgl	Width ft	Dip	Susceptibility cgs units	Methods used*
6	900	150				1
8	1300	750	1000	25°N	4.1×10^{-2}	1, 2
9	3000	400	500	70°SE	3.7×10^{-2}	1, 2, 3
10	150	500	350	10°SE		1, 3, 2
11	270	250	400	60°E		1, 2, 3
12	300	250	r=550			4
13	1000	0	r=700			4
14	920	250	800	80°W		1, 2, 3
15	260	550	1050	55°SE		1, 3
16	160	450	350	30°SE		1, 3
18	86	50	460	50°SSE		1, 3
19	310	1150	1000	70°S		1, 2
20	105	100	700	85°WSW	1.6×10^{-3}	1, 2
21	100	300	460	60°WSW	2.3×10^{-3}	1, 2
22	215	100	160	25°SSE		1, 3, 2
23	210	350		45°S		1, 3
24	90	0	r=500			1, 4
25	250	400	430	30°S	6.2×10^{-3}	1, 3, 2
26	150	450	230	20°S		1, 3
27	150	200	950	55°S		1, 3, 2
28	180	0	320	40°S	1.8×10^{-3}	1, 2
29	700	0	r=420			4
31	200	50				1, 2, 5
32	400	150		45°SE		1, 2
33	460	650	1200	60°E	7.8×10^{-3}	1, 2
34	320	800	1600	60°SE	4.2×10^{-3}	1, 2
38	200	0	r=1750			4, 1, 2
39	340	750	1000	15°SE		1, 2
40	1100	400		40°S		2, 4, 6
41	280	1050	thin	5°S		1, 2

Anomaly No.	Amplitude gammas	Depth ft bgl	Width ft	Dip	Susceptibility cgs units	Methods used*
42	170	750	440	15°SE		1, 3, 2
43	170	50				1, 3
44	100	150	340	30°SSE	1.9×10^{-3}	1, 2
45	130	250	290	30°S	2.8×10^{-3}	1, 2
46	105	100	110	20°S		1, 3
47	70	150		5°S	7.8×10^{-3}	1, 2
48	310	200	r=220			4, 1, 2
49	460	0				1
50	170	150	450	20°WNW	3.1×10^{-3}	1, 2

* 1. Peters (1949), half-maximum-slope method of depth determination

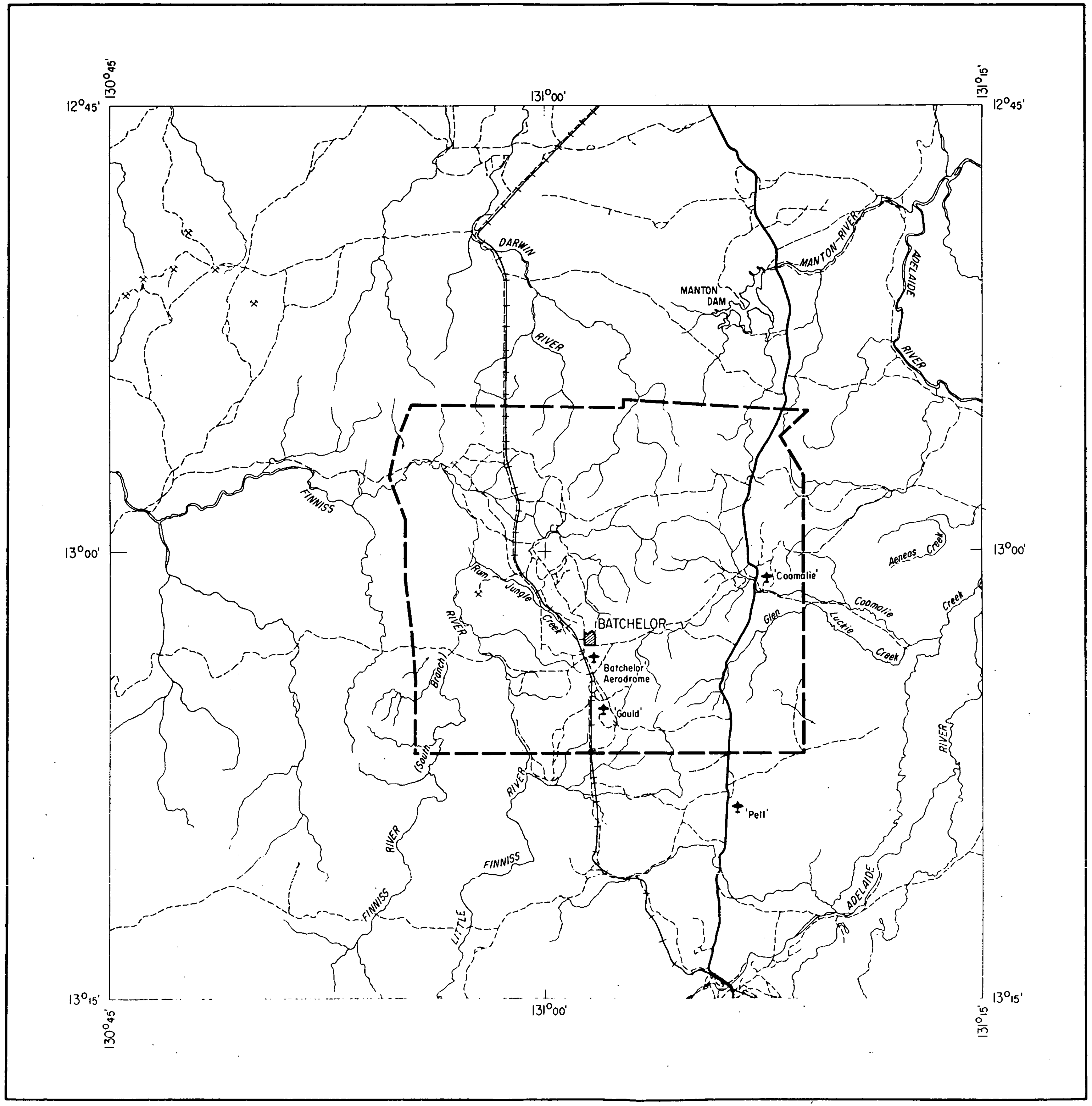
2. Gay (1963), curve-fitting method for tabular bodies
3. Moo (1965), extension of 1 for the inclined prism
4. Daly (1957), depth and radius for spherical bodies
5. Bean (1966), graphical method for tabular bodies
6. Smellie (1956), method for point-poles and point-dipoles

<u>TABLE 2</u>

Sample Letter	Locality	Co-ords Geographical <u>or</u> Rum Jungle East Grid	Number of Samples	Formation	Range of Volumetric Susceptibility (cgs units x 10^{-6})	Mean Value (cgs units x 10^{-6})	Rock Type
A	Castlemaine Hill	13°3½'/131°0½'	2	Buldiva Sandstone	19.8 to 32.3	26.0	Hematitic quartzite & breccia
B	Area 65	13°6'/131°4'	5	Golden Dyke Formation	17.2 to 94.5	53.1	Quartzite
C	Area 65	"	1	Golden Dyke Formation	34.7	34.7	Amphibolite dyke
D	Coomalie Airfield Area	13°1'/131°7'	2	Acacia Gap Tongue	39.7	39.7	Hematitic quartzite
E	West of Woodcutters L3 area	71.75S/31.3W	1	Acacia Gap Tongue	12.5	12.5	Pyritic sandstone
F	Crater Hill area	13°3'/131°2½'	6	Crater Formation	19.8 to 97.0	44.6	Quartzite (arkosic) & Quartzite conglomerate
G	South of Rum Jungle Complex	13°1½'/131°4'	2	Beestons Formation	9.9 to 22.2	16.0	Arkose & siltstone
H	North west of Woodcutters L5 prospect	118S/91W	1	Beestons Formation	1001.0	1001.0	Banded quartz ironstone
I	Rum Jungle Complex near Batchelor	13°1½'/131°4'	1	Rum Jungle Complex	32.2	32.2	Biotite granite
J	"	"	1	Rum Jungle Complex	32.2	32.2	Tourmalized granite

DETAILED AEROMAGNETIC SURVEY, RUM JUNGLE NT, 1967.

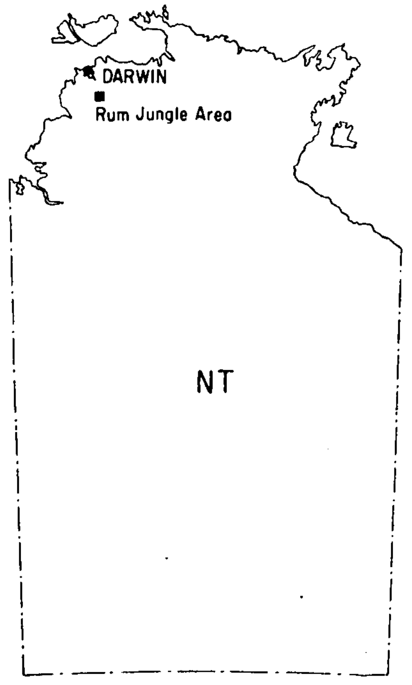
LOCALITY MAP

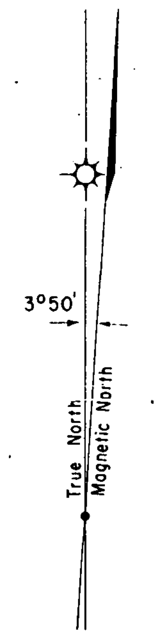


MILES 10 — 0 — 10 — 20 MILES

KILOMETRES 10 — 0 — 10 — 20 — 30 KILOMETRES

LOCATION DIAGRAM





TOPOGRAPHICAL LEGEND

- *River; river or creek*
- *Dam*
- *Highway*
- *Road or track*
- *Railway*
- *Landing ground*
- *Township*
- *Mine*
- *Boundary of survey area*

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. D52/BI-48

TO ACCOMPANY RECORD No. 1970/111

GEOLOGICAL LEGEND

QUATERNARY

Alluvium

UPPER PROTEROZOIC

TOLMER GROUP
BULDIVA SANDSTONE
DEPOT CREEK SANDSTONE MEMBER

Quartz sandstone, with lenses of haematite-rich breccia and lenses of quartz pebble conglomerate

LOWER PROTEROZOIC

RUM JUNGLE COMPLEX

Schist, gneiss, diorite granite, pegmatite etc.

WATERHOUSE COMPLEX

Pgt — Porphyitic granite, and adamellite

Basic intrusives

FINNISS RIVER GROUP
BURRELL CREEK FORMATION

Siltstone, greywacke siltstone, greywacke, quartz greywacke

GOODPARLA GROUP
GOLDEN DYKE FORMATION

Quartz siltstone and carbonaceous siltstone, in places pyritic

MASSON FORMATION
ACACIA GAP TONGUE

Quartz greywacke, quartz sandstone, pyritic and silicified in places; pyritic, carbonaceous siltstone, siltstone

BATCHELOR GROUP
COOMALIE DOLOMITE

Silicified and metamorphosed dolomite

CRATER FORMATION

Quartz greywacke, greywacke, arkose, fine and pebble conglomerate, siltstone

CELIA DOLOMITE

Algal dolomite, in places silicified and metamorphosed, silicified dolomitic breccia, tremolite schist

BEESTONS FORMATION

Arkose, greywacke, siltstone, conglomerate, arkosic conglomerate, white friable quartz sandstone

Geological boundary
Dip and strike of strata
Trend lines
Established synclinal trough–position accurate
Established synclinal trough–concealed; position approximate
Plunge of syncline
Plunge of anticline
Established fault–position accurate
Established fault–position approximate
Established fault–concealed
Probable fault
Quartz vein
Quartz-tourmaline vein
Fossil locality

GEOLOGY AFTER RUM JUNGLE DISTRICT
SPECIAL SHEET, 1:63,360, 1960 EDITION

TOPOGRAPHICAL LEGEND

Highway
Road or track
River or creek
Railway with station and siding
Mine or prospect
Open cut
Dump
Transmission line
Dam

GEOPHYSICAL LEGEND

750 / 800 — Magnetic intensity contours
Magnetic "low"
Positive magnetic trend
Negative magnetic trend
Interpreted fault
23 — Anomaly referred to in text
Granite zone of low magnetic disturbance
A — Sample area for susceptibility measurements

THE MAGNETIC DATA HAVE NOT BEEN CORRECTED FOR THE REGIONAL MAGNETIC GRADIENT

DETAILED AEROMAGNETIC SURVEY, RUM JUNGLE NT, 1967

TOTAL MAGNETIC INTENSITY CONTOURS

GEOPHYSICAL INTERPRETATION

AND

GEOLOGY

1 0 1 2 3 MILES

1 0 1 2 3 4 KILOMETRES

MAGNETIC CONTOUR INTERVAL 10 GAMMAS

TO ACCOMPANY RECORD No. 1970/111
D52/BI-52