DEPARTMENT OF NATIONAL RESOURCES

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1975/149

NEBO COALFIELD MAGNETIC SURVEY, 1974

F.J. Taylor

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SUMMARY

A ground magnetic survey was conducted over proven open-cut coalfields in the Nebo area in the northern part of the Bowen Basin in Queensland. The coalfields surveyed were Kemmis Creek, Walker Creek, Suttor Creek and Poitrel. The aim of the survey was to determine if continuous ground magnetic traversing can be used to define area of intrusions, and to delineate faults. A total of 47 line km of continuous magnetic profiling was completed. The results from the Kemmis Creek area show that several previously unknown dykes cut across the coalfield. These results are the most encouraging as far as the technique is concerned. The results from Walker Creek show magnetic anomalies associated with a large intrusion on the eastern edge of the coalfield.

The magnetic surveys over known faults in all fields were disappointing. From the data obtained there is little room for optimism about the detecting of faults with a magnetometer in conditions found in the Nebo area.

INTRODUCTION

In July 1974 BMR made a ground magnetic survey using a continuous recording technique over selected coalfields in the northern part of the Bowen Basin in north Queensland. The objective was to determine if continuous ground magnetic traversing can be used to define areas of intrusions in proposed open-cut coalfields and to delineate faults.

An area suitable for testing the magnetic technique must satisfy the following conditions.

(1) The proposed open-cut coalfield should have clearly defined regions of intrusions and faults.

(2) The area must be accessible and reasonably free from man-made magnetic noise.

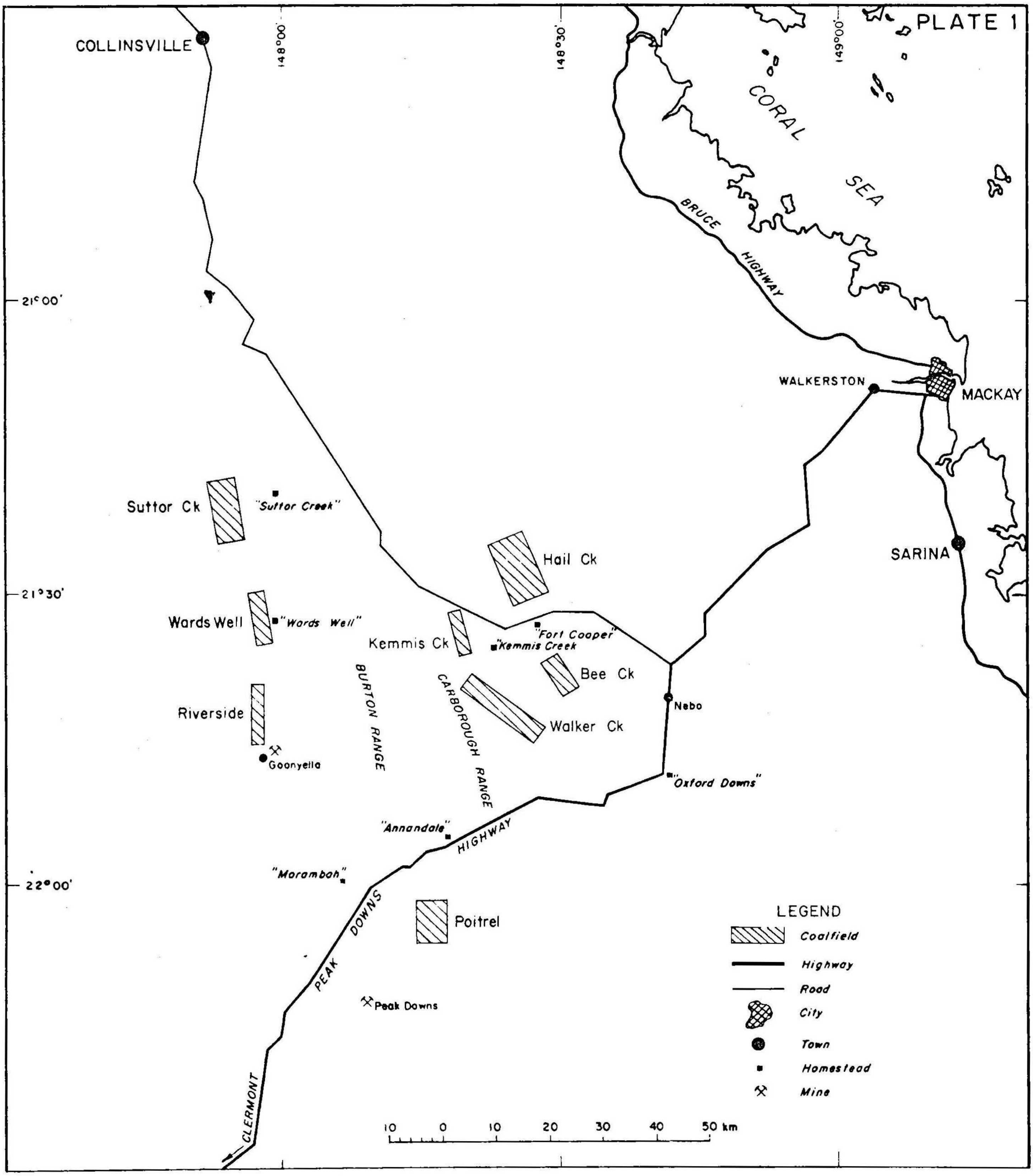
(3) The magnetic anomalies must be associated with intrusions rather than extrusions.

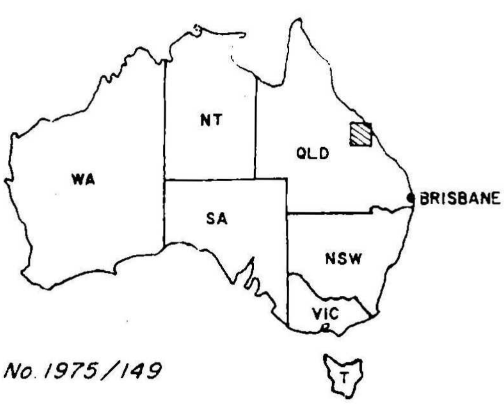
Four coalfields were selected for testing - Kemmis Creek, Walker Creek, Suttor Creek, and Poitrel (Pl. 1).

Kemmis Creek. Of all sites available, this field best satisfies the above conditions. The field is situated on the eastern side of the Carborough Range, about 100 km southwest of Mackay. Only one economic seam is present and its thickness is around 10 m. The seam dips from outcrop to 80 m over a distance of 400 m and the entire field, which is about 10 km long, has been drilled on lines 200 m apart with a hole spacing of about 100 m. One proven area of coking exists and basalt intrusions have been mapped is several drill holes. Several faults with throw ranging from 3 m to 20 m have been mapped over the field (Pl. 2). Thirty-five drill lines, each about 500 m long, were mapped with the magnetometer. Additional traverses were surveyed where required.

Walker Creek. The Walker Creek field lies on the eastern side of the Carborough Range to the south and slightly east of the Kemmis Creek field. The geological setting of this field and the drill sites are similar to that of the Kemmis Creek field. The Walker Creek field is approximately 24 km in length but only a small area of 2 sq km in the vicinity of an outcrop of microdiorite intrusive was investigated with the magnetometer

PLATE 1





LOCALITY MAP, NEBO AREA, NORTHERN BOWEN BASIN

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KEMMIS CREEK MINING AREA

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(Pl. 3). Seven line-kilometres of magnetic traversing was completed.

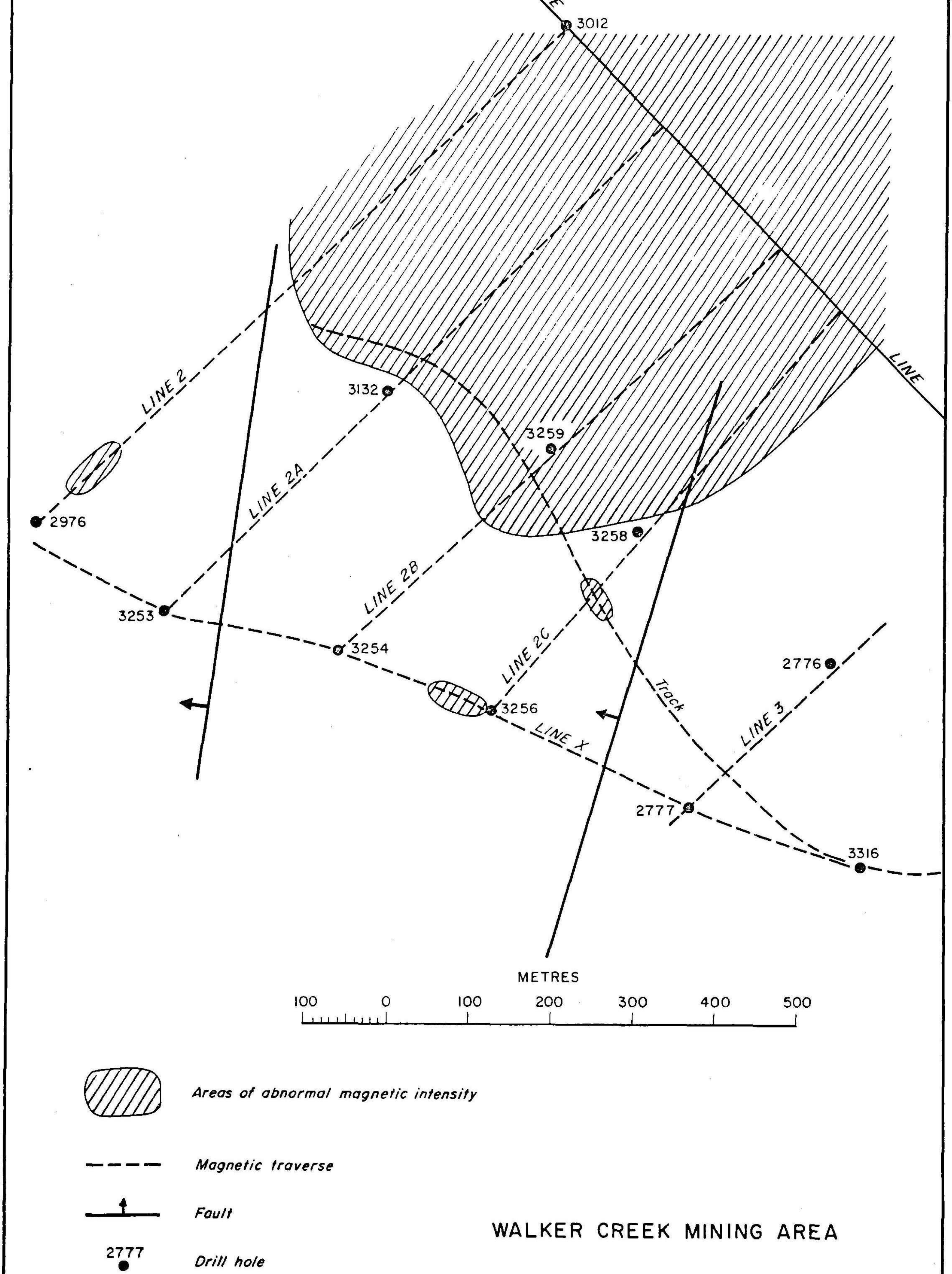
<u>Suttor Creek</u>. The Suttor Creek field lies on the western side of the Carborough Range and is approximately 150 km west of Mackay. The depth of the coal seams varies from 20 m to 250 m and the seams dip gently to the east. The field has been drilled on a broad drill pattern with the holes about 600 m apart. The area is covered by a tertiary basalt capping which gives rise to high magnetic gradients. Most of the coal seams beneath the basalt have been destroyed by coking or intrusion. This area was not considered suitable for detailed testing because of the depth of the coal seams and the presence of overlying surface basalt. However, 4 line kilometres of traversing was completed in this area in order to give some indication of the magnetic variations present (Pl. 4).

<u>Poitrel</u>. The Poitrel field is south of the Carborough Range, on the western side of the Carborough syncline. The field contains only one economic seam, and the depth to the seam varies from outcrop to 60 m. The field is quite large (4 km x 12 km) and no intrusions or coking have been detected. The field has been drilled on lines 200 m apart with a hole spacing of 100 m. Several faults of considerable throw have been mapped in the area. Six line-kilometres of traversing was completed to determine firstly whether faults have a magnetic expression and secondly what magnetic variations are present in the absence of intrusions (Pl. 5).

GEOLOGY

The geology of the area is shown on the Mount Coolon 1:250 000 Sheet together with Explanatory Notes (Malone, 1969) (see also Jensen, 1975). The main structural elements are, from the eastern side, the Connors Arch, Nebo Synclinorium, Collinsville Shelf, Bulgonunna Block, and Anakie High. The Nebo Synclinorium and the Collinsville Shelf were the sites of large thicknesses of Permian-Triassic sedimentation. There sediments are bounded on the east by pre-Permian to Cretaceous volcanics and intrusives, and lie unconformably on Devonian-Carboniferous sediments, volcanics, and intrusives to the west. The complexity of folding and intrusion in the Nebo Synclinorium increases eastwards. The most prominent feature of the Synclinorium is the Carborough Syncline, formed by the resistant Clematis Sandstone.

PLATE 3



WALKER CREEK MINING AREA

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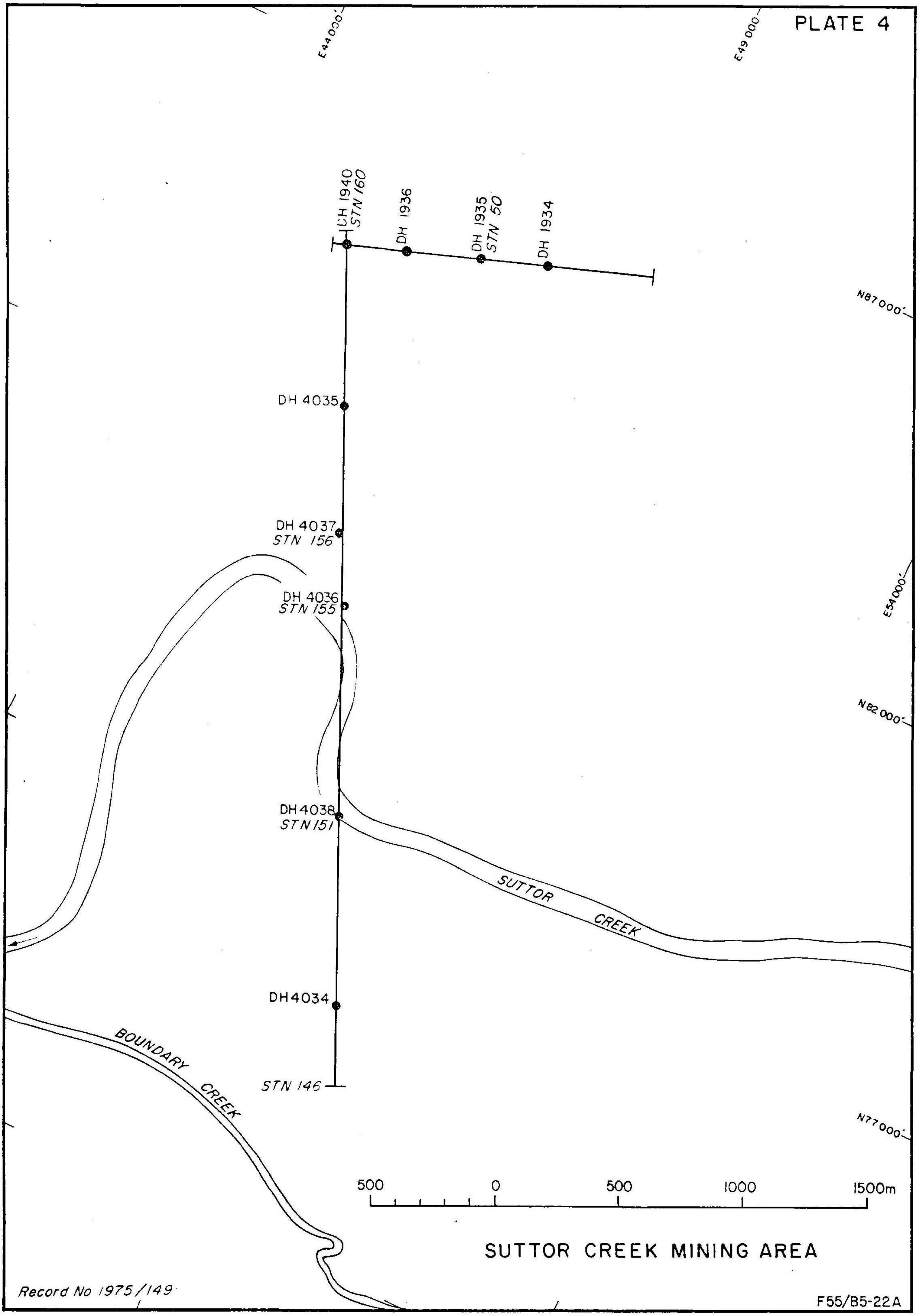
PLATE 4



SUTTOR CREEK MINING AREA

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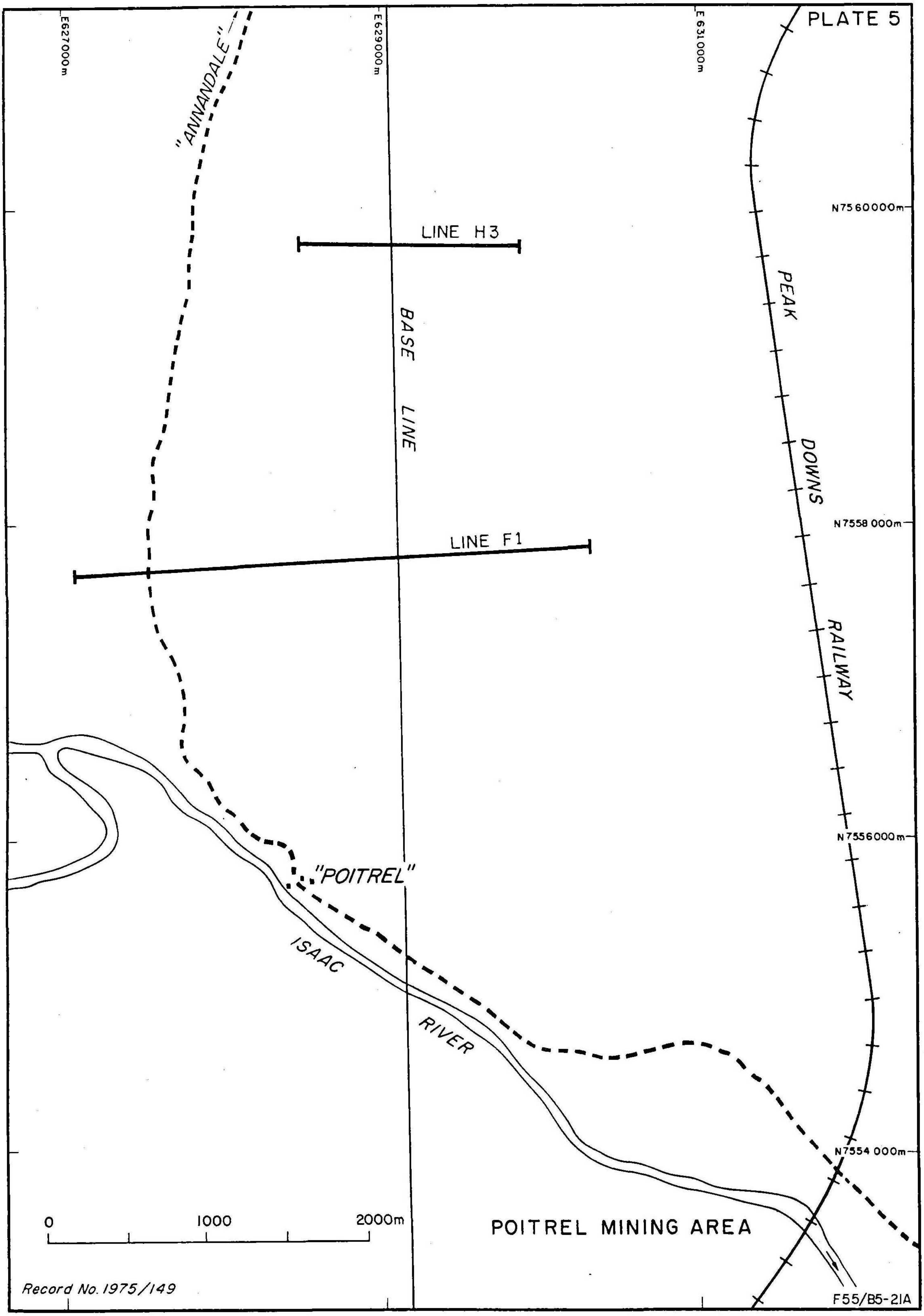

PLATE 5
E627000m
E629000m
E631000m
"ANNANDALE"
N7560000m
LINE H3
BASE LINE
PEAK DOWNS RAILWAY
N7558000m
LINE F1
N7556000m
"POITREL"
ISAAC RIVER
N7554000m
0
1000
2000m
POITREL MINING AREA
Record No. 1975/149
F55/B5-21A

The coal seams currently being mined and investigated lie in the Upper Permian Blackwater Group which outcrops both east and west of the Carborough Syncline. The Triassic Rewan Formation conformably overlies the Blackwater Group and in general the open-cut coal prospects follow the outcrop of the Rewan Formation. Remnants of Tertiary basalt flows and the Tertiary Exevale Formation cover large areas of the Mount Coolon Sheet. This Tertiary cover is particularly widespread to the west and north of the Carborough and Kerong Ranges.

The known coalfields east of the Carborough Syncline include Kemmis Creek, Walker Creek, Bee Creek, and Hail Creek. The Kemmis Creek and Walker Creek fields form outcrops on the eastern edge of the Carborough Syncline and the beds dip west at 15 to 30 degrees. The Hail Creek and Bee Creek fields are part of the Hail Creek syncline. In the Hail Creek field the coal seams outcrop on either side of the syncline.

The sediments west of the Carborough Syncline are part of the more gently dipping Collinsville Shelf sediments. The coal seams dip gently to the east and thus the structure is more suited to large open-cut mines than is that of the outcrops on the eastern side of the Carborough Syncline. Known coalfields in this area include Suttor Creek, Wards Well, Riverside, Goonyella, Poitrel, Peak Downs, and Saraji. The Goonyella, Peak Downs, and Saraji fields are already in production; planning on the Poitrel and Riverside fields is at an advanced stage. The Suttor Creek and Wards Well areas are overlain by several hundred metres of Tertiary sediments and basalt flows.

The main intrusives into the Nebo Synclinorium are of Cretaceous age and are more extensive on the eastern side. Mapped outcrops of Lower Cretaceous intrusives include the Gotthardt Granodiorite, the Bundarra Granodiorite, and the Mount Barker Granodiorite. Not shown on the geological map is an outcrop of microdiorite about 8 km southwest of the Kemmis Creek homestead in the Walker Creek field. Intrusives are known to have severely affected the coal in the Hail Creek and Suttor Creek fields. Vast areas of one coal seam at Suttor Creek have been coked by the action of high-pressure steam and gases; another seam has been effectively destroyed by intrusions.

In general, the sediments associated with the coal seams in the Blackwater group and the sediments of the Rewan Formation are non-magnetic. Hence, any appreciable magnetic disturbances are likely to be associated with intrusions or extrusions. Laterite is known to exist on the surface in some areas but its response is characteristic and could not be confused with that of an intrusion.

METHODS AND EQUIPMENT

It was considered that the success of the project would depend largely on whether a continuous ground magnetic traversing technique could be developed and applied to the particular area. The equipment and techniques employed in obtaining such continuous records are described below. Appendix C gives operational statistics.

A Geometrics 803 proton magnetometer, a 6-inch Moseley Model 680 chart recorder, and a Raytheon d.c. inverter were mounted inside an LWB Landrover panel van and a toroidal detector head was carried by an operator walking 20 m behind the vehicle. One-minute time marks were placed on the chart record by means of a Bulova Acutron electric clock with diode switching (Pl. 16). The speedometer cable of the Landrover was reconnected via a gearbox to a cam which gave relay closures for every 26.9 m of distance travelled.

Traverses were made along drill-line tracks or open country. The magnetometer was cycled to give one recording per second and the value was automatically recorded on the chart recorder. Distance marks and time marks also were automatically recorded on the chart. The speed of the vehicle was such that a magnetometer reading was taken every 1 to 2 metres of distance travelled. Landmarks, such as the locations of drill holes, were noted on the chart record. A chart speed of 2 inches per minute was used. Diurnal variations were obtained using a base station. Three operators were required during traversing.

A check was made to determine the effect of an LWB Landrover on the proton magnetometer (Table 1). The magnetometer detector head was mounted at a fixed location and a Landrover was moved, in stages, from 50 m to 5 m from the detector head. It can be seen from Table 1 that the Landrover has no appreciable effect until the distance is reduced to less than 10 m.

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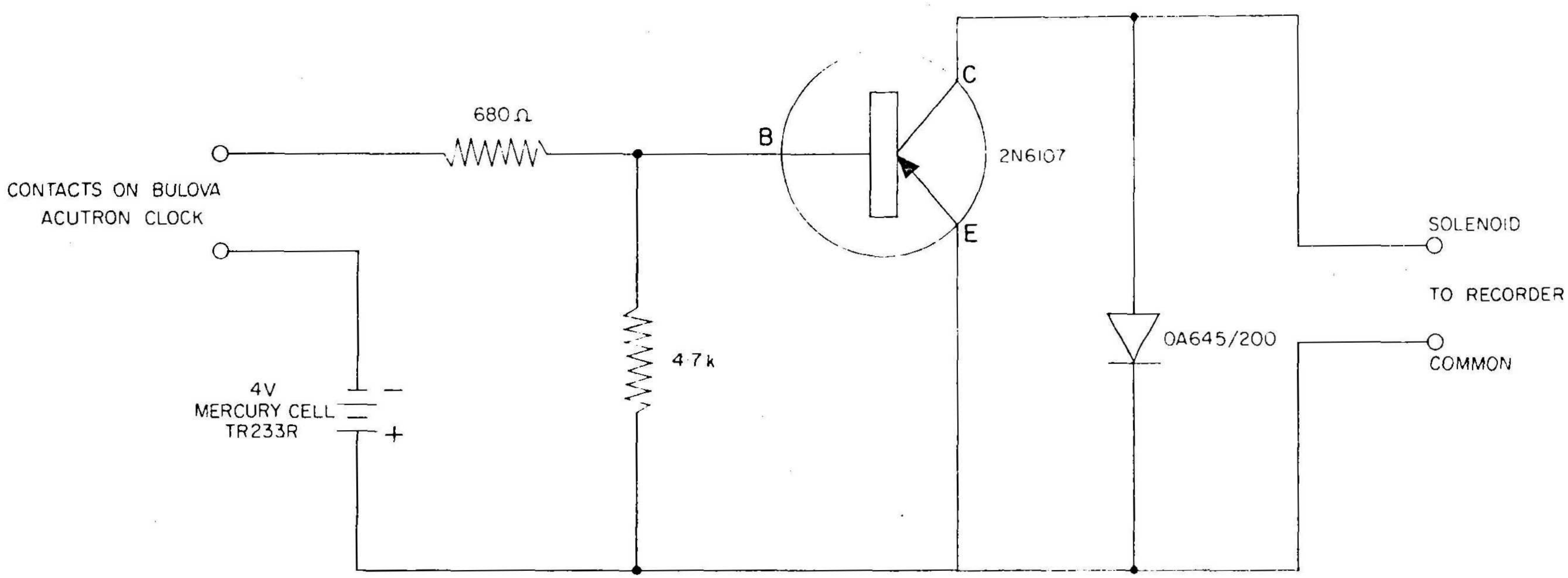


EVENT MARKER CONTROL FOR MOSELEY 680 CHART RECORDER

PLATE 16

F55/B5-24A

TABLE 1. Effect of LWB Landrover on proton magnetometer

Distance between Landrover and detector head (m)	Observed magnetic field (nT)
50	50909
40	50909
30	50909
20	50908.5
15	50908
10	50904
5	50865

The above system was used to obtain all field results reported in this Record. However, the system is not perfect and requires the following modifications to improve performance:

(1) The magnetometer cycling rate of 1 cycle/second with an output of 100 nT for full-scale deflection is unsatisfactory in areas where the magnetic field varies abruptly. Improved results would be obtained on some occasions if the cycling rate were 2 cycles/second with a full-scale deflection of 200 nT.

(2) The noise level in the system when the magnetometer head is stationary is less than 0.5 nT. However, whenever the head is moved, as for example when traversing, the noise level rises to 3 nT. It becomes even greater with increasing head temperature. A noise level of 3 nT does not prevent useful results from being obtained but it is clearly a nuisance.

(3) The method of noting distance on the chart record is inherently inaccurate. A better method would be one where the speedometer cable drives the chart record.

(4) Although a toroidal detector was used, the system relies too much on the detector's being orientated normal to magnetic north. The use of a more enriched proton source should help to eliminate this dependeance on orientation by giving higher signal levels. Kerosene was used in the detector head for this survey.

(5) The technique of carrying the detector head 20 m behind the vehicle works quite well but requires an extra operator. If the head could be mounted on a pole attached to the vehicle and corrections made for the influence of the vehicle then the speed of operation would be improved.

Such systems are currently on the market but the author is not familiar with their operation.

RESULTS

General. Continuous magnetic profiles were obtained for the following areas.

Area	Drill lines	Distance covered (km)
Kemmis Creek	1 - 8	30
Walker Creek	2 - 3	7
Suttor Creek	1, 2	4
Poitrel	Base, F1, H3	6

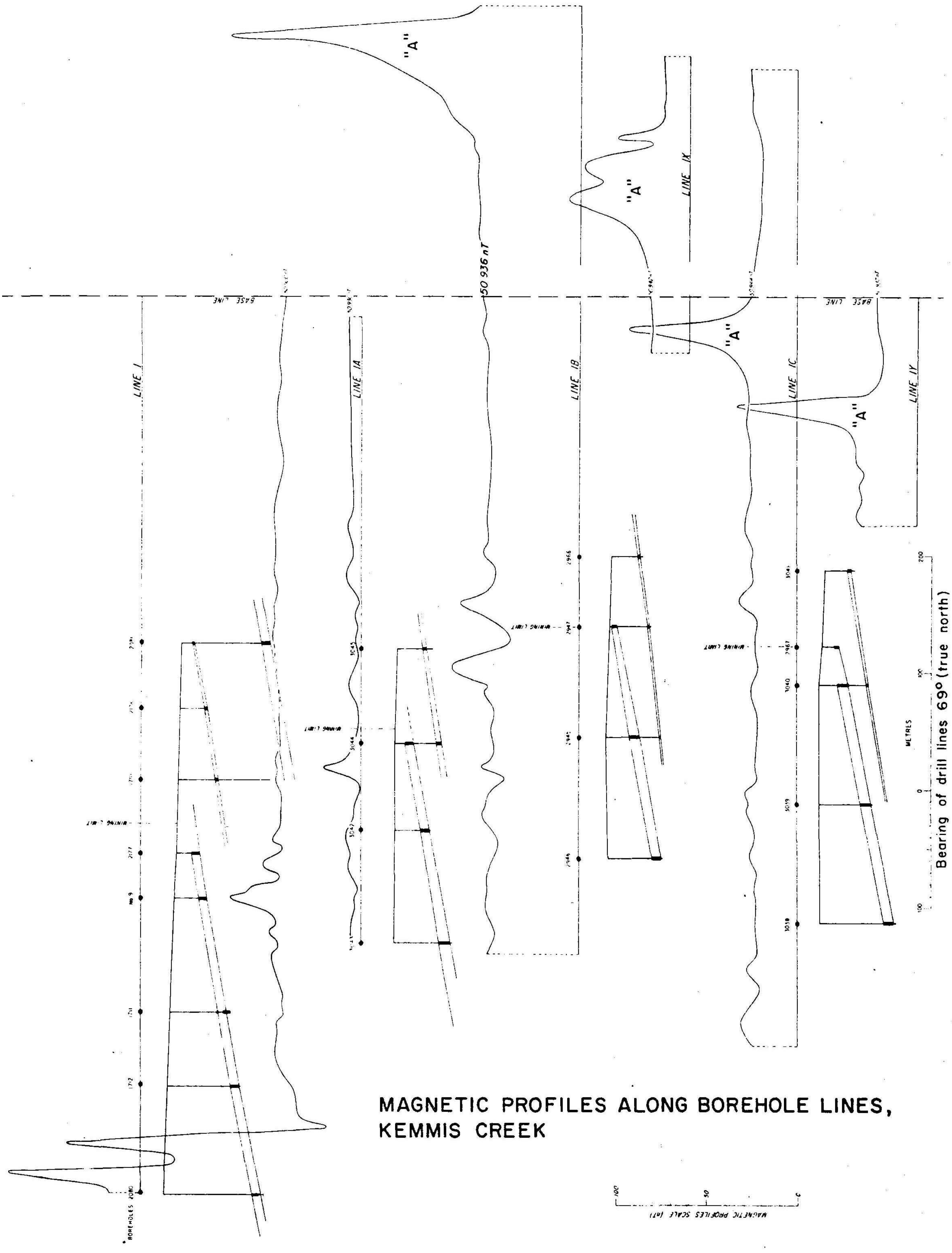
Anomalies due to intrusions range in amplitude from 100 to 1000 nT. Anomalies due to surface laterite and remanence of the Tertiary basalt capping were high-frequency erratic anomalies with amplitudes up to 50 nT. Anomalies due to man-made material such as star pickets, drill casing, and general rubbish were eliminated from the magnetic profiles whenever such situations could be verified.

The results from the Kemmis Creek area are presented as magnetic profiles along each of the drill lines investigated (Pls 6 to 13). The results from the Walker Creek area are indicated as anomalous magnetic areas on the plan (Pl. 3) while the results from Suttor Creek and Poitrel (Pls 4, 5) are commented on without presentation of the profiles. All profiles are available for inspection at the Bureau of Mineral Resources, Canberra.

Kemmis Creek. The results from this area are the most interesting and the most encouraging as far as the technique is concerned. A series of narrow anomalies which have a peak amplitude in the order of 100 nT can be traced across the coalfield. The linear nature of these anomalies and the fact that the sources were not detected in drill holes leads the author to believe that they are produced by thin, near-vertical dykes. The anomalies are labelled A, B, C, D, and E on Plates 6 to 13.

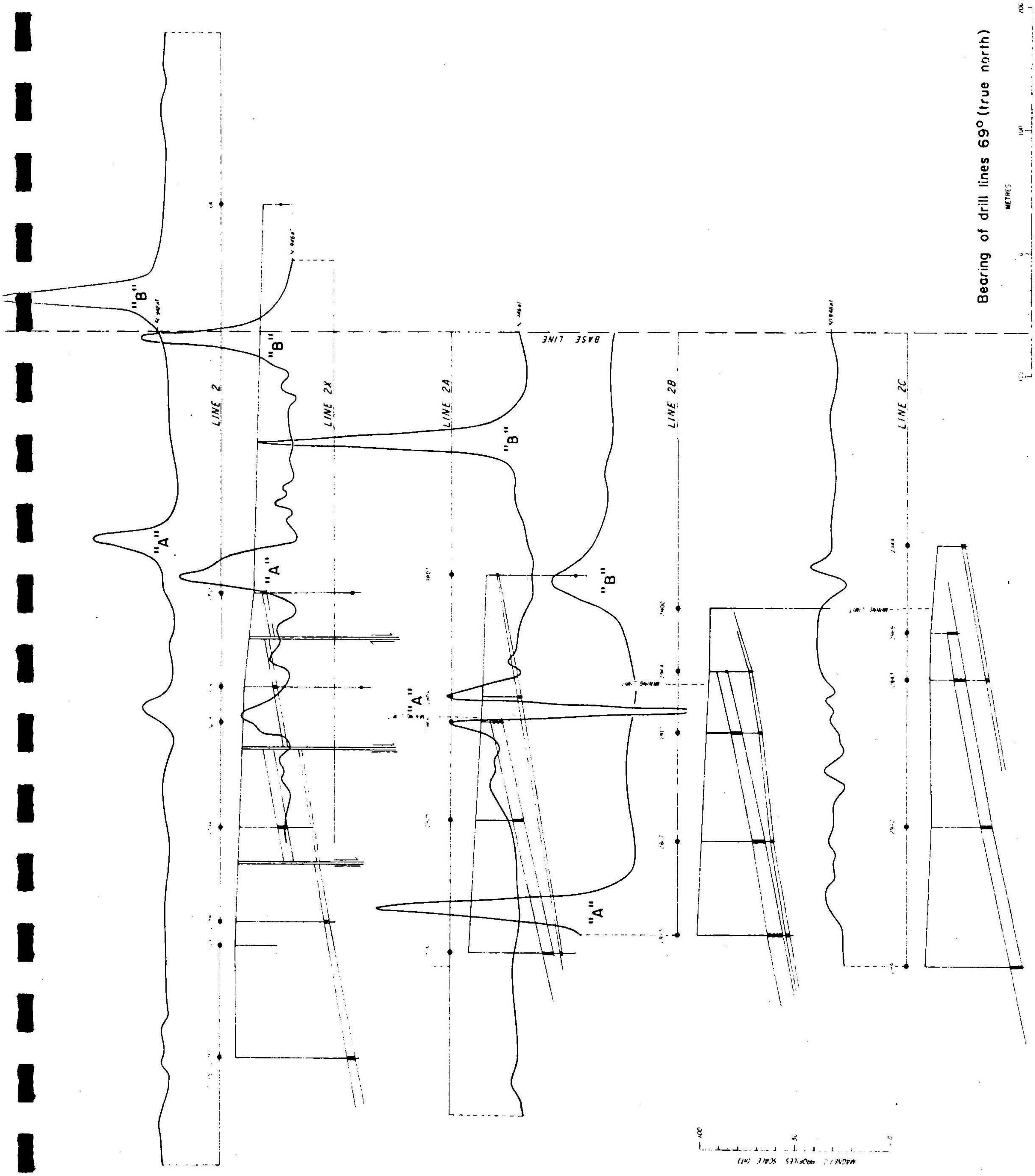
Selected cross-sections of these anomalies were analysed using a computer program (see Appendix A) based on thin infinite dykes. The results are summarised in Table 2, and some interpretations are illustrated

PLATE 6



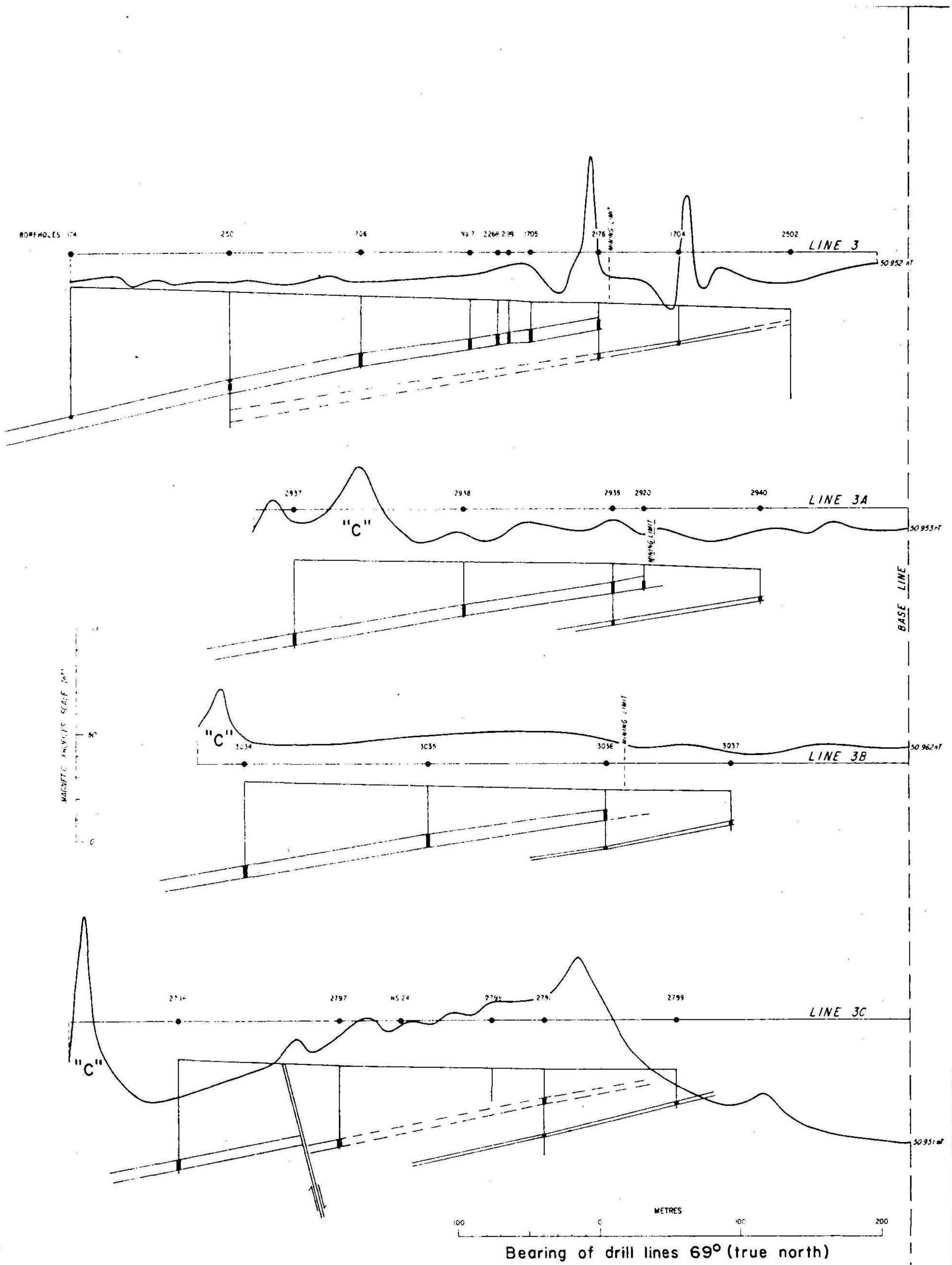
MAGNETIC PROFILES ALONG BOREHOLE LINES, KEMMIS CREEK

PLATE 7



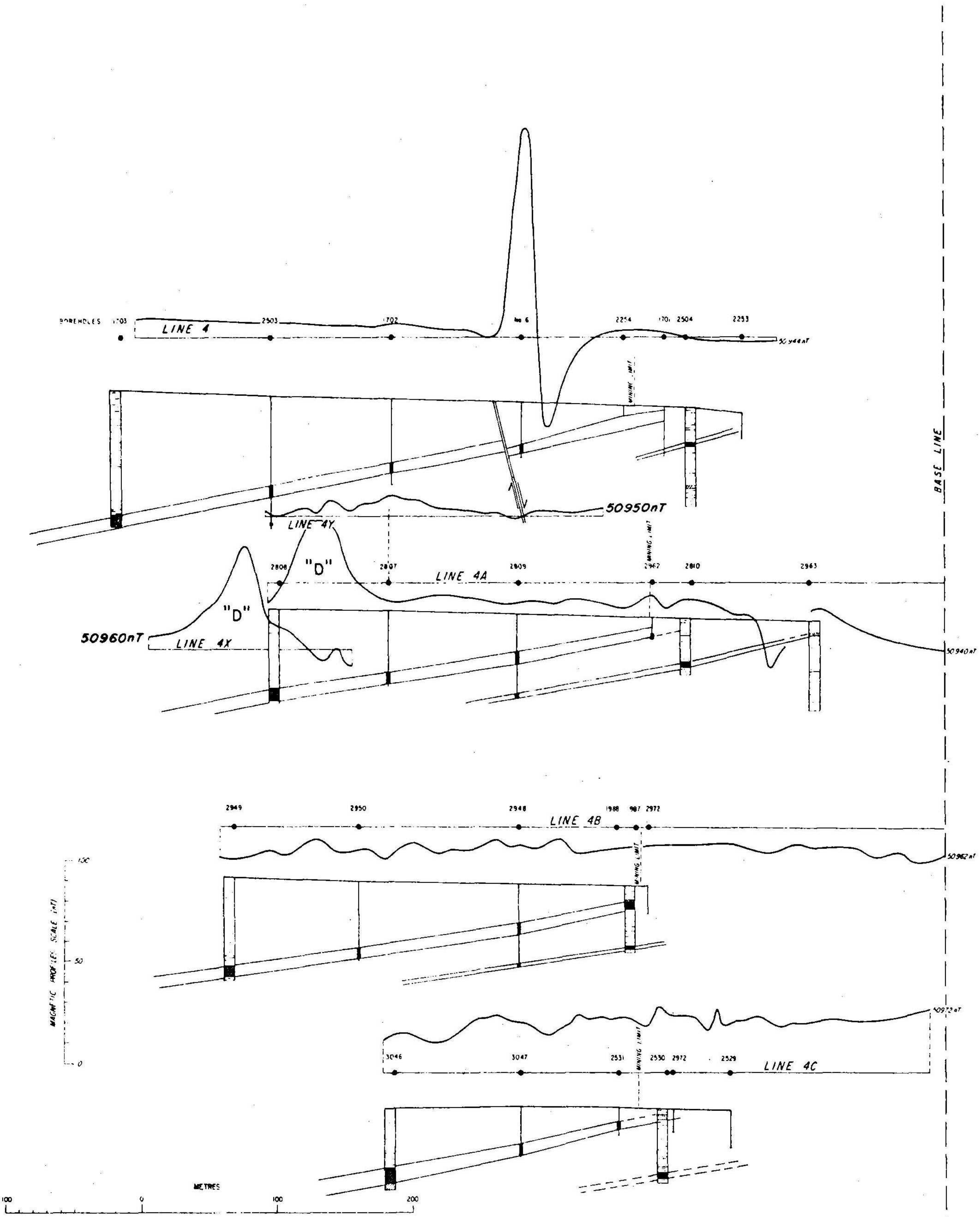
MAGNETIC PROFILES ALONG BOREHOLE LINES, KEMMIS CREEK

PLATE 8



MAGNETIC PROFILES ALONG BOREHOLE LINES, KEMMIS CREEK

PLATE 9



Bearing of drill lines 69° (true north)

MAGNETIC PROFILES ALONG BOREHOLE LINES, KEMMIS CREEK

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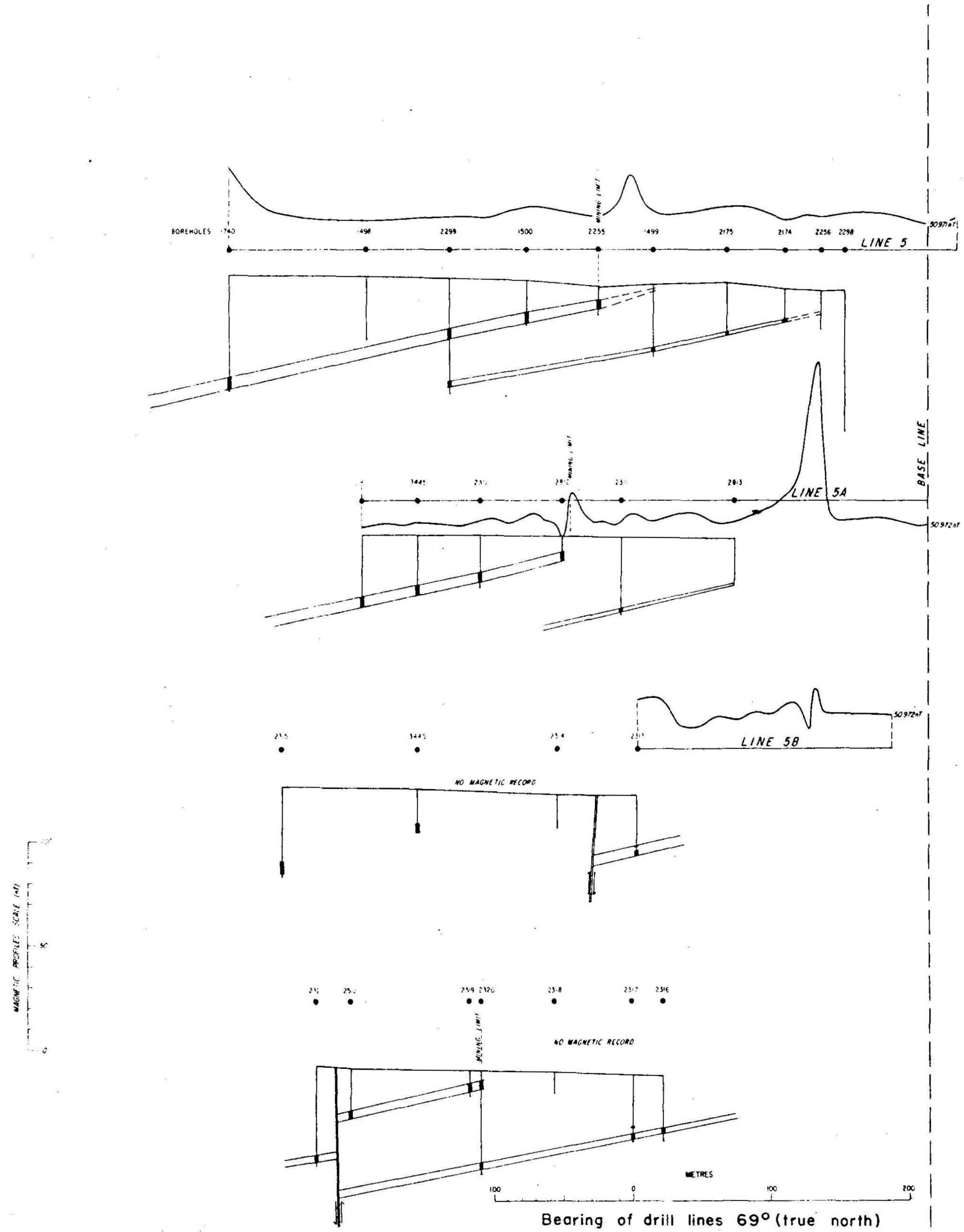
PLATE 10



MAGNETIC PROFILES ALONG BOREHOLE LINES, KEMMIS CREEK

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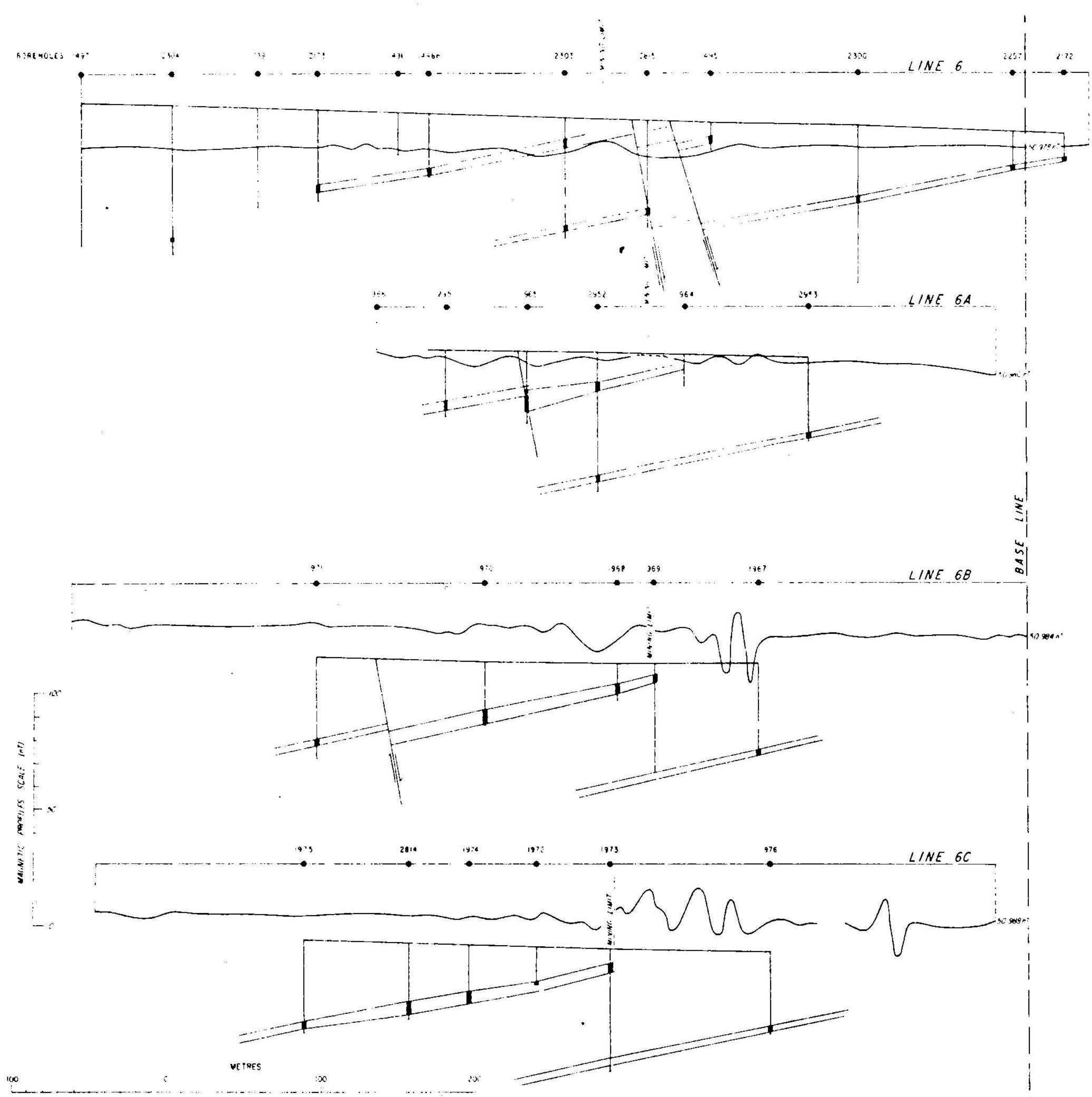
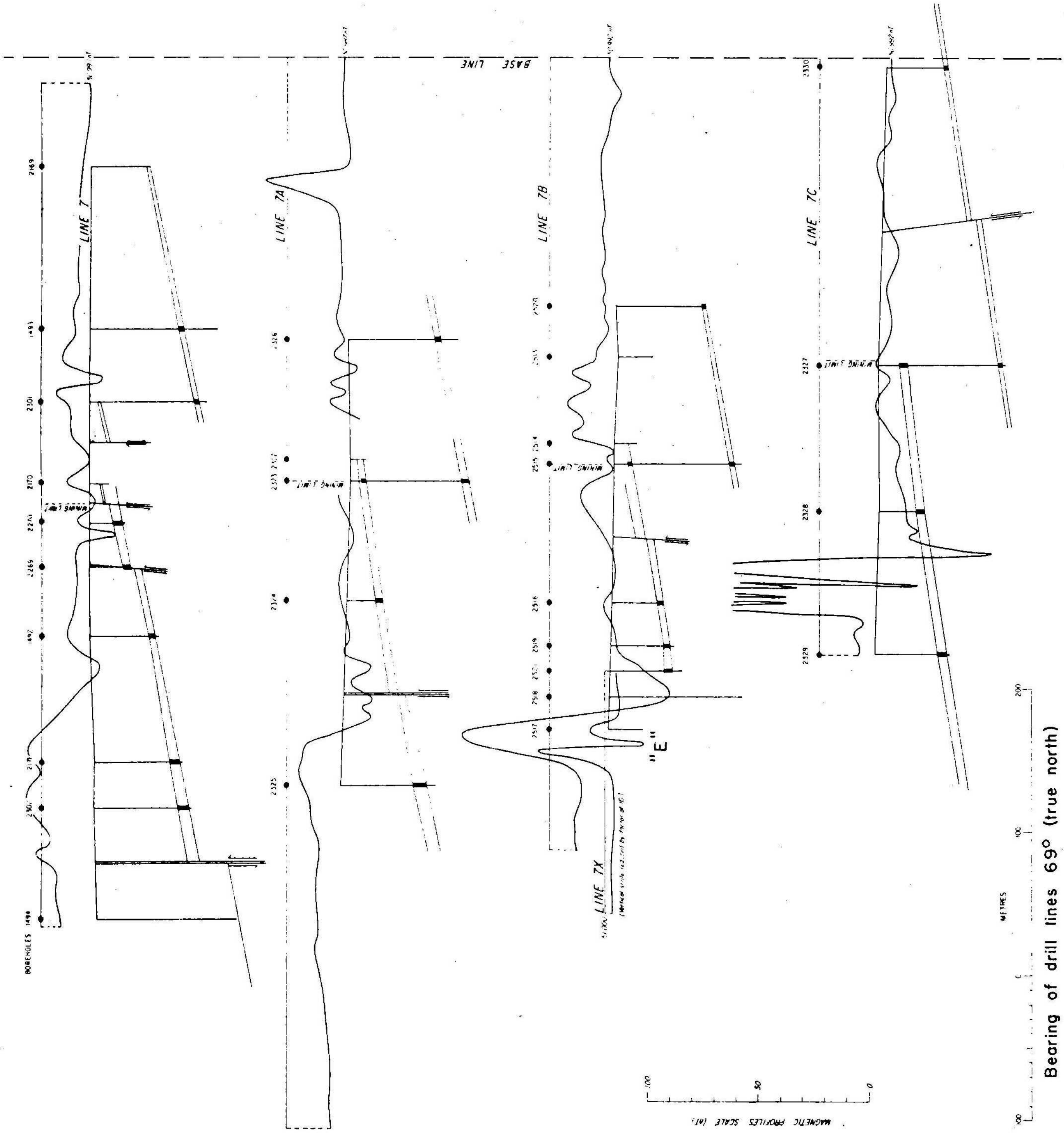
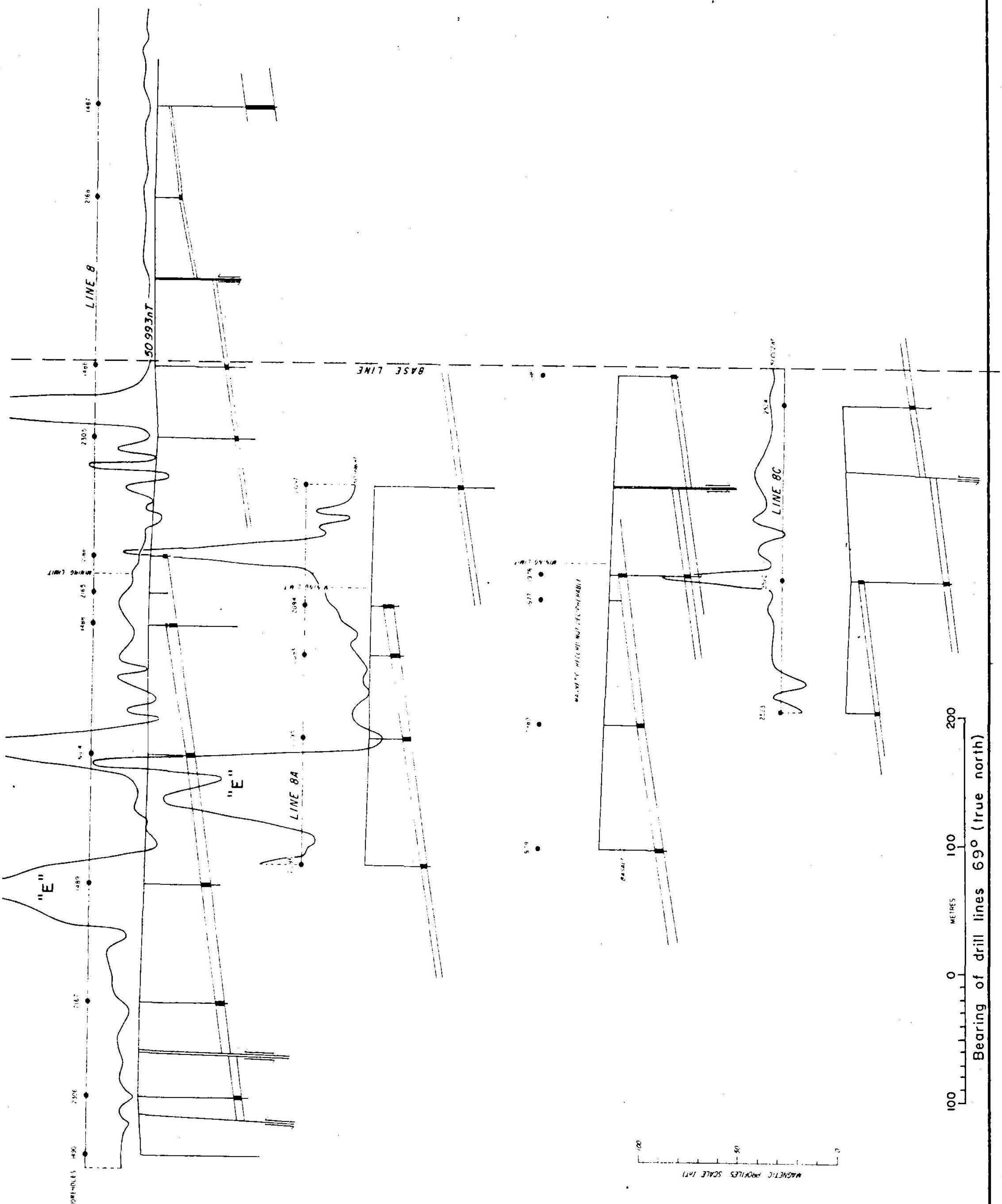


Bearing of drill lines 69° (true north)

MAGNETIC PROFILES ALONG BOREHOLE LINES, KEMMIS CREEK



MAGNETIC PROFILES ALONG BOREHOLE LINES, KEMMIS CREEK



MAGNETIC PROFILES ALONG BOREHOLE LINES, KEMMIS CREEK

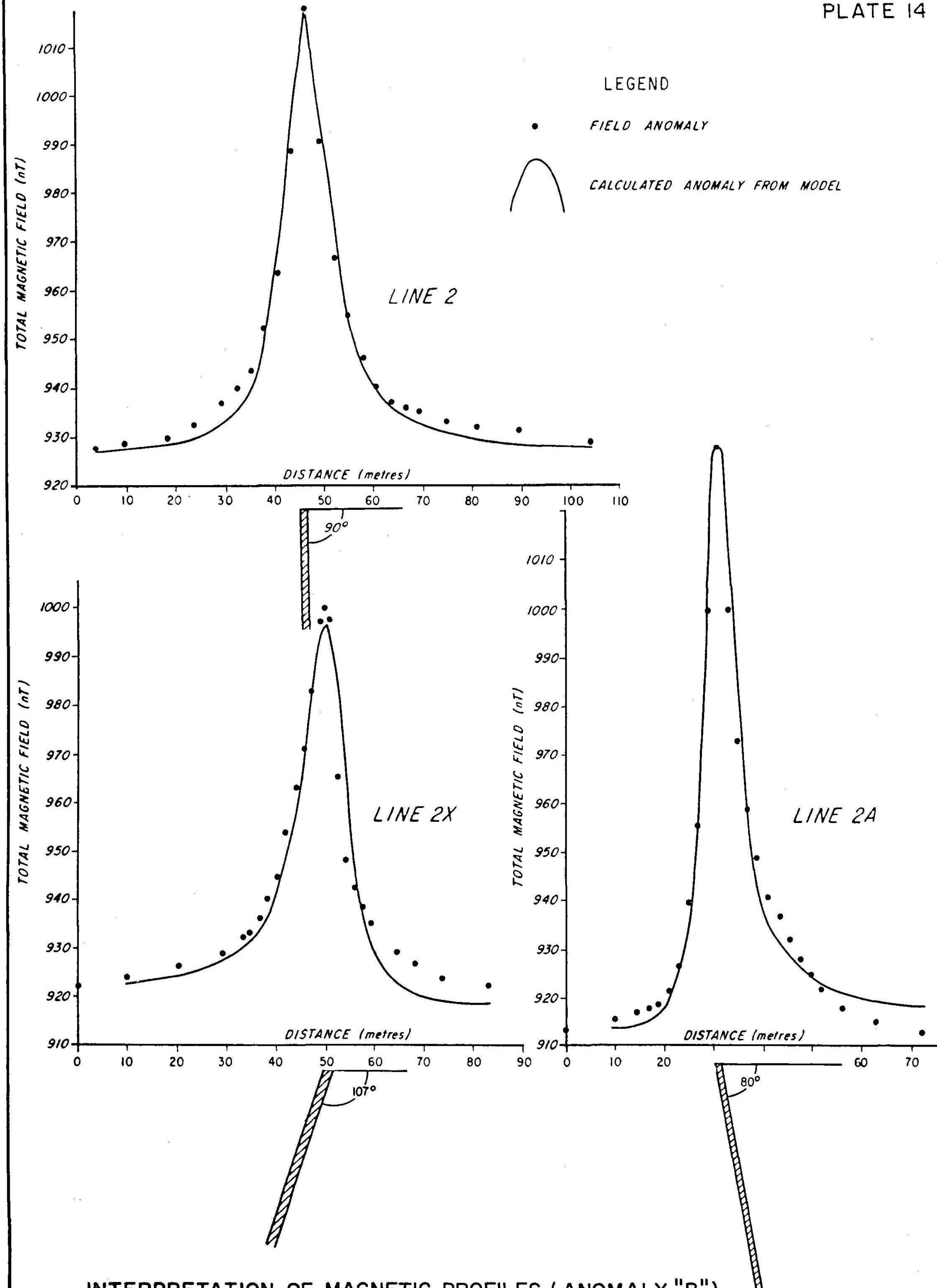
in Plate 14.

Anomaly A strikes approximately 8°E and extends from the north-eastern end of Line 1B to the southwestern end of Line 2B, a distance in excess of 1 km. Anomaly B lies parallel to Anomaly A and can be traced over about 500 m. Both anomalies are interpreted as being due to thin, near vertical dykes whose upper limits are about 5 m below the ground surface.

Table 2. Interpretation of linear magnetic anomalies as dykes, Kemmis Creek area

Anomaly	Strike (true)	Line	Depth to top of inferred dyke (m)	Dip of inferred dyke, relative to northern half plane (degrees)
A	8°E	1C	5.5	72
		1Y	4	75
B	7°E	2	5	90
		2X	5	105
		2A	3.5	80
C	7°E	3A	16	115
		3B	6-8	110
		3C	4	104
D	26°E	4A	12	100
		4X	10.5	100
E	150°E	7B	10	?
		7X	Surface	?

Anomaly C can be traced across Lines 3A, 3B, and 3C and is parallel to Anomaly A. The anomaly is interpreted as a thin dyke, the depth to which increases from 4 m on Line 3C to 16 m on Line 3A.



INTERPRETATION OF MAGNETIC PROFILES (ANOMALY "B")

Anomaly D is evident on Lines 4A and 4X. Line 4X lies approximately 50 m to the south of Line 4A and parallel to it. The anomaly is interpreted as a thin dyke whose top is about 10 m beneath the surface. This anomaly was not detected on Line 4Y, which is north of Line 4A. The strike of the anomaly is 26°E.

Anomaly E is obvious on Lines 7B and 7X and to some extent on Line 7 and 7A. However, the strike of the anomaly is not clearly defined on lines southeast of Line 7X. Anomalies present on Lines 7C, 8, 8A, and 8B all indicate near-surface magnetic material, and could be attributed to a sill rather than thin near-vertical dykes. The magnetic profile recorded on Line 8B is not shown here because the rapid changes in the magnetic field could not be deciphered from the record obtained. Basalt has been logged in some of the drill holes around this area but no intrusion or coking of the coal seam has been detected.

The coked area detected by drilling in the vicinity of Line 3C does not show any sharp anomalies typical of the dykes described above. However, a broad anomaly of peak amplitude 50 nT and half-width approximately 200 m exists on this line. A similar anomaly was mapped along the base line between Lines 3B and 3C, indicating the strike to be approximately 30°E. Such an anomaly is caused by a comparatively deep and large magnetic body. This is consistent with the concept that the extent of coking of a coal seam depends more on the quantity of heat available rather than the proximity of an intrusion.

Magnetic anomalies which were not traced over any distance were detected at the southwestern end of Lines 1 and 5. The anomaly on Line 1 is due to near-surface magnetic material; that on Line 5 was not mapped sufficiently to obtain a depth estimate.

Walker Creek. Magnetic profiles were obtained over seven lines in the vicinity of a large microdiorite intrusive. The intrusive cropsout on the eastern side of the coalfield near Lines 2, 2A, 2B, and 2C. Plate 3 shows a plan of the area indicating the extent of abnormal magnetic disturbance. The magnetic field varies rapidly across the intrusion and anomalies as large as 100 nT were detected. Three smaller, isolated anomalies were also detected on Lines X, 2, and 2C indicating that thin dykes may radiate across the field from the main body of the intrusion.

The two faults shown are not reflected in the magnetic profiles. In fact, Line X was carried out primarily to determine whether the faults would show some magnetic expression.

Suttor Creek. The work at the Suttor Creek field consisted of 3.9 km of magnetic profiling along two drill lines (Pl. 4). Line 1 covered the area between Holes 1940 and 1934. Line 2 covered the area between Holes 1940 and Station 146 with a break at Suttor Creek. Coal seams in the area occur from surface to depths of 250 m, and most show intrusion or coking.

The magnetic profiles obtained show variations of up to 100 nT, due to surface laterite and basalt extrusions. The only feature worth noting is a large anomaly 250 m north of Hole 4034, in approximately the same location as the edge of the basalt capping that occurs extensively to the south of this area.

Poitrel. A total of 6 km of magnetic profiling was carried out along the baseline, Line F1, and Line H3 (Pl. 5). There are no known intrusions in this area but there are at least 10 well-defined faults intersecting the magnetic profile lines.

The magnetic profiles do not show any anomalies indicative of intrusions. Small high-frequency anomalies were detected in some isolated areas and are attributed to surface laterite. There is no observable magnetic effect associated with any of the mapped faults.

The conclusions reached from the work at Poitrel are (1) there is little probability of intrusions and hence coking occurring in this field, and (2) the magnetometer is not successful in delineating faults in coal seams in this area.

CONCLUSIONS

The continuous magnetic traversing was successful in delineating intrusions at Kemmis Creek and Walker Creek. The anomalies detected at Kemmis Creek illustrate that the technique can be used to detect and map dykes over a fairly large area. The absence of anomalies attributable to intrusions in the Poitrel area confirms the drilling results. However, the use of the technique in areas such as Suttor Creek is futile, owing to the overlying basalt extrusives and the depth to the coal seams.

On all four areas investigated there is an abundance of well-defined faults indicated by drill holes. However, there is no evidence of any of these faults showing a magnetic expression. This is illustrated by Plate 15 which shows a cross section over a fault on Line 8, Kemmis Creek, with the associated magnetic profile. The original field data were filtered to remove the noise caused by movement of the detector head. The filtered plot does not show any anomaly attributable to the fault.

The equipment and technique used for this survey could be made more efficient, and distances of up to 50 km per day could be covered by two men with one vehicle.

A major factor in the ease of operation of this technique is the good access in the particular area of this survey.

Acknowledgements

The author is thankful for the assistance given by staff of Thiess Peabody Mitsui at Mackay, Qld and in particular John Sedgeman. Thanks also to the staff of the Geological Survey of Queensland.

References

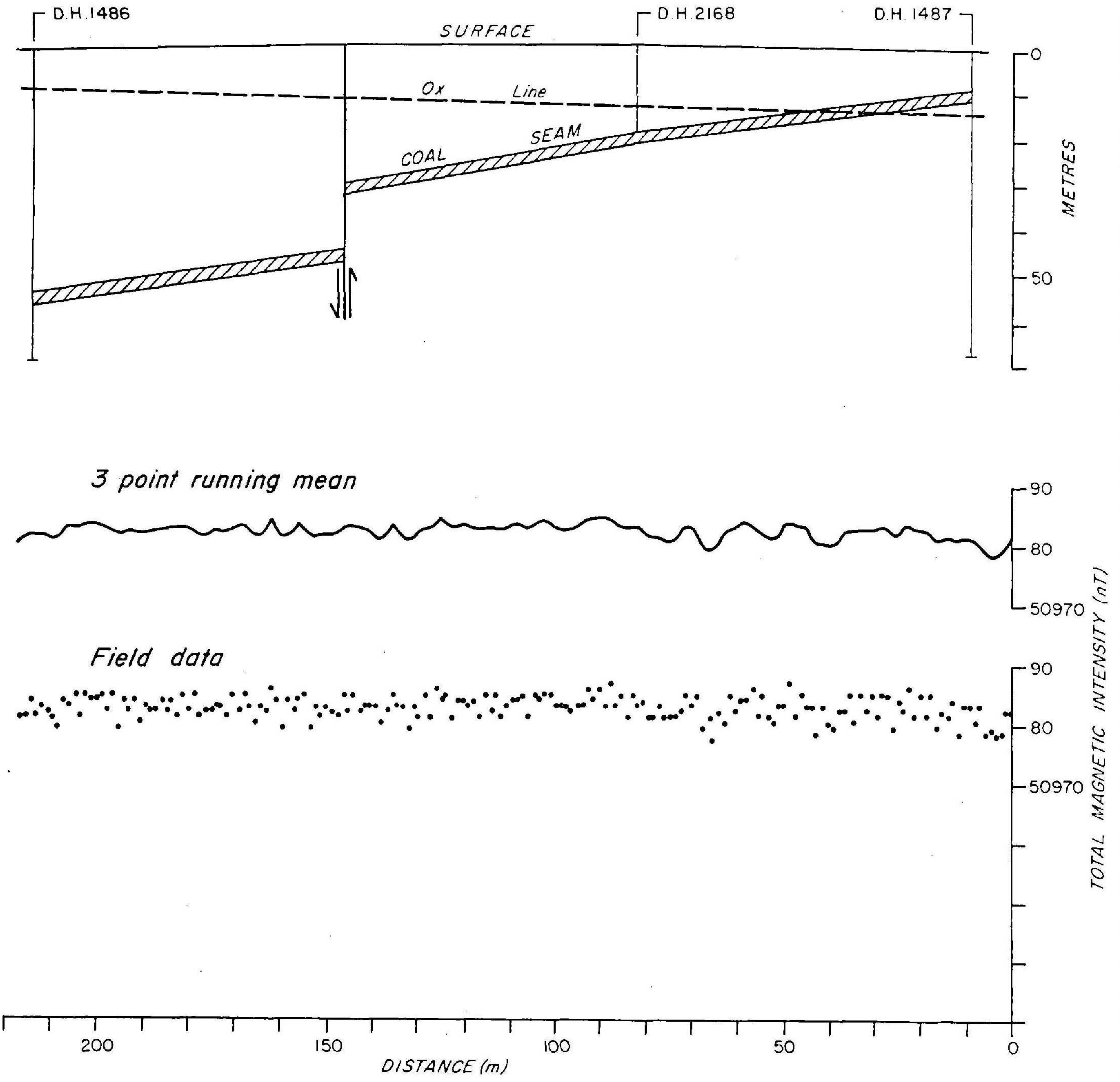
JENSEN, A.R., 1975. Permo-Triassic stratigraphy and sedimentation in the Bowen Basin, Queensland. Bureau of Mineral Resources Bulletin 154.

MALONE, E.J., 1969. 1:250,000 Geological Series - Explanatory Notes. Mt Coolon, Qld.

Appendix A. Analysis of a thin infinite dyke using a computer program

Methods of interpreting magnetic anomalies due to thin dykes are given by Haigh & Smith (1975), Parker Gay (1963), and many other authors. These authors give a set of standard curves where parameters such as thickness of dyke, dip, location, and depth are varied. The method of

LINE 8 KEMMIS CREEK COALFIELD



MAGNETIC PROFILE ACROSS FAULT

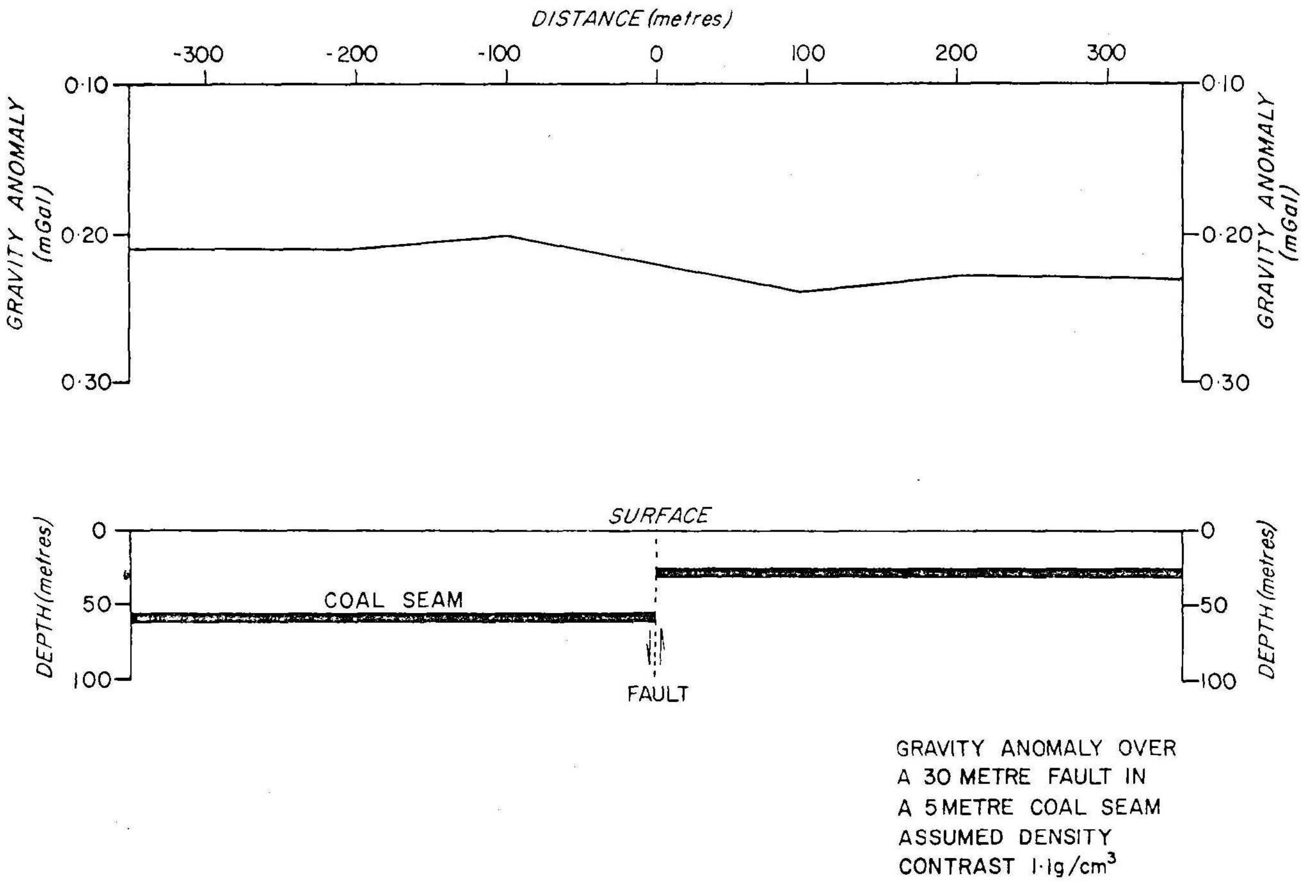
interpretation is to adjust the horizontal and vertical scales of the plotted field anomaly and compare the result with the standard curves.

The method of interpretation used in this report is essentially as outlined above except that a programmable desk-top calculator was used to obtain a least-squares fitting of a proposed model and the field data. In this method, the parameters are changed either manually or automatically until the best least-squares fit is obtained. (References: (1) HAIGH, J.E. & SMITH, M.J., 1975 - Standard curves for interpretation of magnetic anomalies due to thin finite dykes. Bureau of Mineral Resources Bulletin 152. (2) PARKER GAY, S., 1963 - Standard curves for interpretation of magnetic anomalies over long tabular bodies. Geophysics. 28(2)).

Appendix B. Theoretical Gravity Anomaly

The author has considered the use of gravity techniques to detect faults in near-surface coal seams. Plate 17 shows the expected gravity anomaly in the case of a 5-m coal seam at a depth of 30 m. The seam is shown faulted, with a throw of 30 m. The theoretical gravity anomaly shown in milligals was derived from a 3-D computer gravity program in which the areal extent of the block considered was 2 km square.

The theoretical anomaly shown in the plate is of the order of 0.05 mGal. Variations of this order could be expected from both minute, near-surface density changes, as well as from variations in equipment. Hence there is little doubt that the gravity meter is unlikely to be of use in mapping faults in open-cut coal fields.



THEORETICAL GRAVITY PROFILE OVER A FAULTED COAL SEAM

Appendix C. Operational Statistics

Personnel

Party Leader	F.J. TAYLOR
Geophysicist	D. RAMSAY
Mechanic	D.K. McINTYRE
Field Assistant	L. RICKARDSSON

Statistics

No. of days of field work	16
Distance covered	47 km

Equipment

Magnetometer	Geometrics 803 proton.
	BMR MNS2 proton.
Chart Recorder	Moseley Model 680, 6-inch.
Power	Raytheon D.C. inverter with two 12-v batteries.

Vehicles

2 Landrovers	Panel vans
1 Toyota	Station wagon