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WESTERN VICTORIA DETAILED AEROMAGNETIC SURVEY, 1966

by

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SUMMARY

In parts of western Victoria deposits of brown coal are covered by basalt flows. These deposits can be mined economically only where the basalt is thin or absent. In 1966 the Bureau of Mineral Resources made an aeromagnetic survey of two areas in western Victoria to determine whether the magnetic method could be used to measure basalt thickness. The results of the survey are presented in the form of total magnetic intensity contours and their significance is discussed.

The basalt of western Victoria consists of overlapping flows which vary in their direction of remanent magnetisation; consequently a reliable method for measuring basalt thickness was not evolved. However, in areas where the underlying rocks are relatively nonmagnetic it was found that 'windows' in the basalt cover of the order of one mile or more in diameter can be outlined by a qualitative analysis of the magnetic data. By this means certain parts of the Hamilton survey area are interpreted as being either free of basalt cover or covered by basalt which is so weathered that it has lost its magnetic properties. It is proposed that these areas be investigated on the ground to test this interpretation.

A method for improving the efficiency of data processing for future surveys of this type is suggested.

1. INTRODUCTION

Within the next few years, the Geological Survey of toria will undertake an exploration programme for brown coal in western Victoria. Much of the area that has brown coal potential is overlain by basalt, but where this is thin or sufficiently decomposed, underlying brown coal may possibly be mined economically. The Geological Survey of Victoria requested that the Bureau of Mineral Resources make an aeromagnetic survey of parts of the Western Plains of Victoria with the aim of predicting the thickness and state of decomposition of the basalt cover. With this information, the Geological Survey of Victoria could select areas in which to do drilling tests for brown coal deposits.

In order to test the feasibility of determining the thickness and state of decomposition of the basalt, the BMR made a survey over two areas: one of 56 square miles immediately north and north-east of the township of Creswick; and the other over an area of 89 square miles north-east of Hamilton (Plate 1). These areas have little or no potential for brown coal deposits but the state of the basalt is known from the results of a number of shallow drill holes.

Creswick is 60 miles west-north-west of Melbourne and 9 miles north of Ballarat, previously one of the major gold mining centres of Australia. During the second half of the 19th century, there was a considerable amount of mining activity in the district. Much of the information on the state of the basalt cover in the survey area was obtained after the period of intense mining activity, in an effort to map the 'deep lead' system of the old river beds underlying the basalt.

Hamilton, 100 miles west of Ballarat, is an agricultural centre. There has not been any mining activity in Hamilton, but the state of the basalt is known from a number of holes drilled recently to investigate underground water resources.

2. GEOLOGY

The geological information for the survey was obtained from Baragwanath (1953), Coulson (1954), Gill (1964), Hunter (1909), Oliver and Joyce (1964), and Yates (1954). Information on the Hamilton area was obtained from Spencer-Jones (1965). Palaeomagnetic information was obtained from Green and Irving (1958), Irving and Green (1957), and Green (1959).

Creswick area

The major formation in the Creswick area (Plate 2) is the Ordovician slates and sandstones. This underlies the whole of the survey area and all the surrounding country. It is folded into a series of north-striking synclines and anticlines. The formation has been intruded by minor dykes, both acid and basic. It contains numerous faults, many of which have been infilled by quartz. Minor Pliocene river sediments occur in the old valleys eroded into the Ordovician rocks.

Overlying the Pliocene sediments and completely infilling the old valley system are basalt flows of Pliocene and Pleistocene age. These flows are part of the extensive volcanic activity that took place throughout Western Victoria. This activity commenced at the end of the Miocene period and finished with an explosive phase in Recent times. Much of western Victoria was covered with olivine basalt flows and tuff. This sequence (up to a few hundred feet thick) consists of a number of basalt flows, which often show distinct differences in composition. The basalt was derived from numerous volcanoes, which are now apparent throughout western Victoria as low hills 200 to 400 ft high. These are usually lava or scoria cones and domes. In the survey area, extinct volcanoes exist at Spring Hill (scoria dome), Forrest Hill (scoria dome), Green Hill, and Lord Harry Hill (scoria dome).

Recent alluvium derived from the Ordovician slates and sandstones and the basalt flows occur along the rivers and creeks; recent soil derived from decomposed basalt overlies the basalt flows.

Hamilton area

Basalt lava flows overlie the major part of the survey area (Plate 4) and extend south over the Western Plains of Victoria. In the west of the survey area the basalt is in contact with the Upper Devonian Rocklands Rhyolites. To the north and east, the basalt overlies Tertiary sediments, which abut the Upper Devonian-Lower Carboniferous Grampians Group. The probable succession in the survey area is:

Pleistocene basalt flows
Tertiary laterites and gravels
Upper Devonian-Lower Carboniferous Grampians Group
Upper Devonian Rocklands Rhyolites
Ordovician sandstones and slates.

The Ordovician rocks consist of sandstones, greywackes, shales, and slates. There are few outcrops in the vicinity of the survey area and these are deeply weathered and capped by laterite. The folding is probably along north-south axes.

The Rocklands Rhyolites are porphyritic and well-banded rhyolites, rhyodacites, agglomerates and tuffs occurring south-west of the Grampian Ranges. Generally, the Rhyolites have a north-north-west strike and dip gently east-north-east. Most of the holes drilled in the survey area bottomed in rhyolites.

The Grampians Group forms the strike ranges of the Grampians to the north-east of the survey area. The rocks are predominantly quartzose sandstones with siltstone and some mudstone. The succession is unfossiliferous and mainly of freshwater origin. A thickness of 20,000 ft has been estimated for the Group but how much of this, if any, is present under the basalt flows in the survey area is unknown. The sandstone strata are gently folded and tilted with dips that are predominantly west and south-west.

The Tertiary deposits are mainly of terrestrial origin. The base of these deposits consists of ferruginous sands, gravels, clay, and concretionary ironstones. Part of the succession consists of ironstones containing marine Tertiary fossils probably representative of the marine transgression of the Murray Basin in Oligocene-Miocene times. To the north and north-west of the survey area there is a large area of ferruginous deposits, termed laterites, capping the tableland surface, which extends south-west from the Grampians. Most of the laterites formed in situ on Palaeozoic rocks but some of the deposits contain transported sands and angular reef quartz gravels. To the north-east of the survey area there are fluviatile deposits of Pliocene to Pleistocene age. The deposits are unfossiliferous, coarse to medium sands, gravels, and clays. To the south-east of the Grampian Ranges they appear to pass beneath the basalts.

The basalt lava flows covering most of the survey area are comparatively young and are dated as being of Pleistocene age. These are contemporaneous with the younger basalt flows in the Creswick area. The basalts are grey-black in colour, vesicular and usually fresh in outcrop. There are no known volcanoes in the survey area, but north of Hamilton, Mount Bainbridge is a weathered basalt dome with a distinguishable crater form. South and south-east of Hamilton there are extinct volcanoes at Mount Pierrepoint (a rounded basalt hill), Mount Napier (a multiple scoria cone), and at Mount Rouse (a composite hill, mainly scoria cone but with a well defined basalt crater to the south). South of Hamilton there is possibly an east-south-east striking fault, which marks the northern limit of the Otway Basin. The above-mentioned volcanoes probably lie along or close to this fault zone.

Palaeomagnetic samples taken by Green and Irving from the basalt flows throughout western Victoria showed normal and reverse remanent magnetisation in the direction of the Earth's present magnetic field.

3. RESULTS

Creswick area

A direct correlation exists between the geological map (Plate 2) and the magnetic contour map (Plate 3) for the Creswick area. Over the areas of basalt cover, the magnetic field is extremely disturbed, whereas over the areas of Ordovician slates and sandstones, the field is relatively undisturbed. However, there is no distinct change of field over the boundary between the basalt and the slates and sandstones, rather a gradual change from disturbed field to undisturbed field spread over a distance of about half a mile.

The intensity of the magnetic field appears to vary randomly from point to point over the basalt. The thickness of the basalt in numerous bore holes was obtained from Annual Reports, Drilling Reports, and Boring Records of the Victorian Department of Mines and plotted on the geological map (Plate 2). A comparison of Plates 2 and 3 shows that there is no clear relation between the thickness of the basalt and the magnetic field intensity measured above the basalt. This is to be expected, as the rock sequence consists of a number of basalt flows which vary in thickness and in composition (from dense hard rock to light vesicular basalt) throughout the areal extent of the individual flows, and which are interspersed with layers of clay, sand, and gravel. The flows can be expected to vary in the strength of their induced magnetisation, as well as their remanent magnetisation, and the remanent magnetisation may be either normal or reversed in direction.

A non-random feature of the magnetic field over the basalt is the occurrence of a large amplitude anomaly over each hill. This suggests that all the hills in the basalt area are extinct volcanoes with basalt cores of relatively high magnetic susceptibility. As some of the associated anomalies are negative in polarity, the cores must be remanently magnetised. Positive amplitude anomalies occur over Clover Hill, the low hill at 37° 20' S/143° 58' E, Woodhouse Hill, Green Hill (north of Kingston), Cattle Station Hill, and Forrest Hill. Negative amplitude anomalies occur over Green Hill (west of Allendale) and Lord Harry Hill, indicating that these hills are extinct volcanoes whose cores exhibit reverse remanent magnetisation, that is, the volcanoes became extinct during a period when the Earth's field was in reverse polarity. Spring Hill is an extinct volcano that gives rise to both negative and positive amplitude anomalies.

A prominent feature on the magnetic contour map is a line of negative, large amplitude anomalies extending from Creswick through Broomfield and Allendale, across to Kingston and Newlyn, and north through Smeaton. The position of the anomalies corresponds exactly to that of the main electric transmission line running north from Creswick. Several ground traverses made with a fluxgate magnetometer failed to detect this anomaly, consequently it is attributed to transmission line interference with the airborne proton precession magnetometer and should be disregarded.

Hamilton area

As in the Creswick area, the magnetic field over the area of basalt cover (Plate 4) is disturbed. Unlike the results for the Creswick area, a study of the contour map does not enable the area of basalt cover to be differentiated from the other geological units.

In the western part of the survey area the magnetic field is disturbed over the Tertiary laterites and gravel and over the Rocklands Rhyolite, as well as over the basalt. It is unlikely that the western boundary of the basalt could be determined from the magnetic results alone, although the boundary is roughly marked by a magnetic feature, namely a region of low magnetic field intensity. The outcropping Rocklands Rhyolite gives rise to a slightly disturbed magnetic field, whereas the outcropping Tertiary rocks give rise to a moderately disturbed magnetic field. This disturbance is probably caused by underlying rhyolite or rhyodacite rather than by the Tertiary gravels and laterites.

In the north-eastern part of the survey area, the magnetic results do not delineate the boundary of the basalt, as the adjacent rock units also give rise to a disturbed magnetic field. This disturbance is probably associated with beds in the Grampians Group that underlie the Quaternary and Tertiary sediments. The magnetic contours exhibit a north-west trend, which reflects the strike of these beds.

In the south-eastern part of the survey area, there are regions mapped as basalt where the magnetic field is undisturbed. These are outlined in Plate 4 and were derived from a study of the magnetic profiles along individual flight lines. The boundaries were determined by plotting the points on the profiles at which the field changed from disturbed to undisturbed. It is proposed that these areas of undisturbed field correspond to areas of Tertiary sands, gravels, clays, and laterites with or without a thin cover of weathered basalt.

The thickness of the basalt determined from holes drilled to test underground water resources are plotted in Plate 4. As found in the Creswick area, there is no deterministic relation between the thickness of the basalt and the magnetic field intensity measured above the basalt. However, there is an apparent relation between the thickness of the basalt and the amount of variation of the magnetic field intensity, for example, the peak to peak amplitude of the numerous magnetic anomalies is small over areas of thin basalt cover. In Plate 4, the two holes in which no basalt was found are close to the boundary of the area of undisturbed magnetic field. Other holes close to this boundary revealed about 40 ft of basalt, which contrasts with thicknesses of about 100 ft in other areas.

The Hamilton survey area did not contain any hills in the area covered by basalt, and the magnetic results did not show any large amplitude anomalies that could be attributed to the cores of volcanoes.

4. CONCLUSIONS

The results of surveying in both the Creswick and Hamilton areas show that an absolute measure of the thickness or the state of decomposition of the basalt flows cannot be obtained from the measurements of the intensity of the total magnetic field. However, the results from the Hamilton area indicate that the relative thicknesses of the basalt in different areas can be determined under certain conditions, namely, when the basalt overlies a rock unit that has no effect on the Earth's magnetic field as measured in this survey. Under these conditions, detailed aeromagnetic surveying can also delineate areas within which there is no basalt or where the basalt is too thin and weathered to have a measurable effect on the magnetic field. Such a method is probably adequate for the purpose of locating drill holes to test for brown coal deposits.

The results from the northern part of the Hamilton area show that few conclusions can be drawn about the basalt from the aeromagnetic data when the basalt is in contact with other rock units, such as the Rocklands Rhyolite, which also affect the magnetic field.

The results at Creswick indicate that detailed aeromagnetic surveying can detect 'windows' in the basalt of the order of one mile or more in diameter. However, the geological environment at Creswick is not as typical of the prospective brown coal areas of western Victoria as that found in the southern part of the Hamilton area. At Creswick the basalt flows have filled the valleys of an old river system cut into steeply dipping Ordovician slates and sandstones. In the brown coal environment, the horizontal basalt flows overlie horizontal Tertiary sediments.

In Plate 4, areas have been delineated within which there is very little variation in the intensity of the magnetic field. These are interpreted as areas of no basalt or areas where the basalt is thin and highly weathered. It is recommended that some shallow holes be drilled in these areas to test this conclusion. If it is proved correct, further aeromagnetic surveying could be undertaken to locate positions for drill holes in western Victoria.

Future surveys need not involve the amount of work expended in obtaining the contour maps for the Creswick and Hamilton areas. It should be sufficient to inspect the magnetic records for sections within which there are no short-period anomalies due to shallow sources, then to plot these sections on the relevant map, and thus outline the areas in which there is a negligible amount of basalt.

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APPENDIX

Operational details

Survey specifications

Detector altitude	: Creswick area - 250 ft above ground level
	Hamilton area - 350 ft above ground level
Line spacing	: One-tenth of a mile between adjacent flight lines
Line direction	: East-west
Recorder sensitivity	: 1st recorder - 100 gammas f.s.d.
	2nd recorder - 10,000 gammas f.s.d.
Magnetometer cycle time	: 0.85 second
Diurnal correction	: Applied correction rounded off to nearest one gamma
Area surveyed	: Creswick area - 56 square miles
	: Hamilton area - 89 square miles
Flight-line miles	: Creswick area - 532 miles
	Hamilton area - 930 miles
Survey commenced	: 20th April 1966
	1st part finished 4th July 1966
	2nd part commenced 17th October 1966
Survey finished	: 31st October 1966

Equipment

Aircraft	: Cessna 180
Magnetometer	: BMR proton precession type MNS1 (P)
Recorders	: 2 x Moseley Autograph
Camera	: Modified Vinten frame, 35-mm, 186° field of view
Radio altimeter	: AN/APN-1

Method

A correction for diurnal variation was determined by flying a baseline at the beginning and end of each survey flight. The standard baseline level for the survey was the level of the baseline obtained on the first survey flight in each of the survey areas. The diurnal correction was applied on the assumption that the diurnal magnetic field varied in a linear manner during any one survey flight.

The airborne magnetometer records accepted for survey data showed a noise envelope of between 4 and 15 gammas.

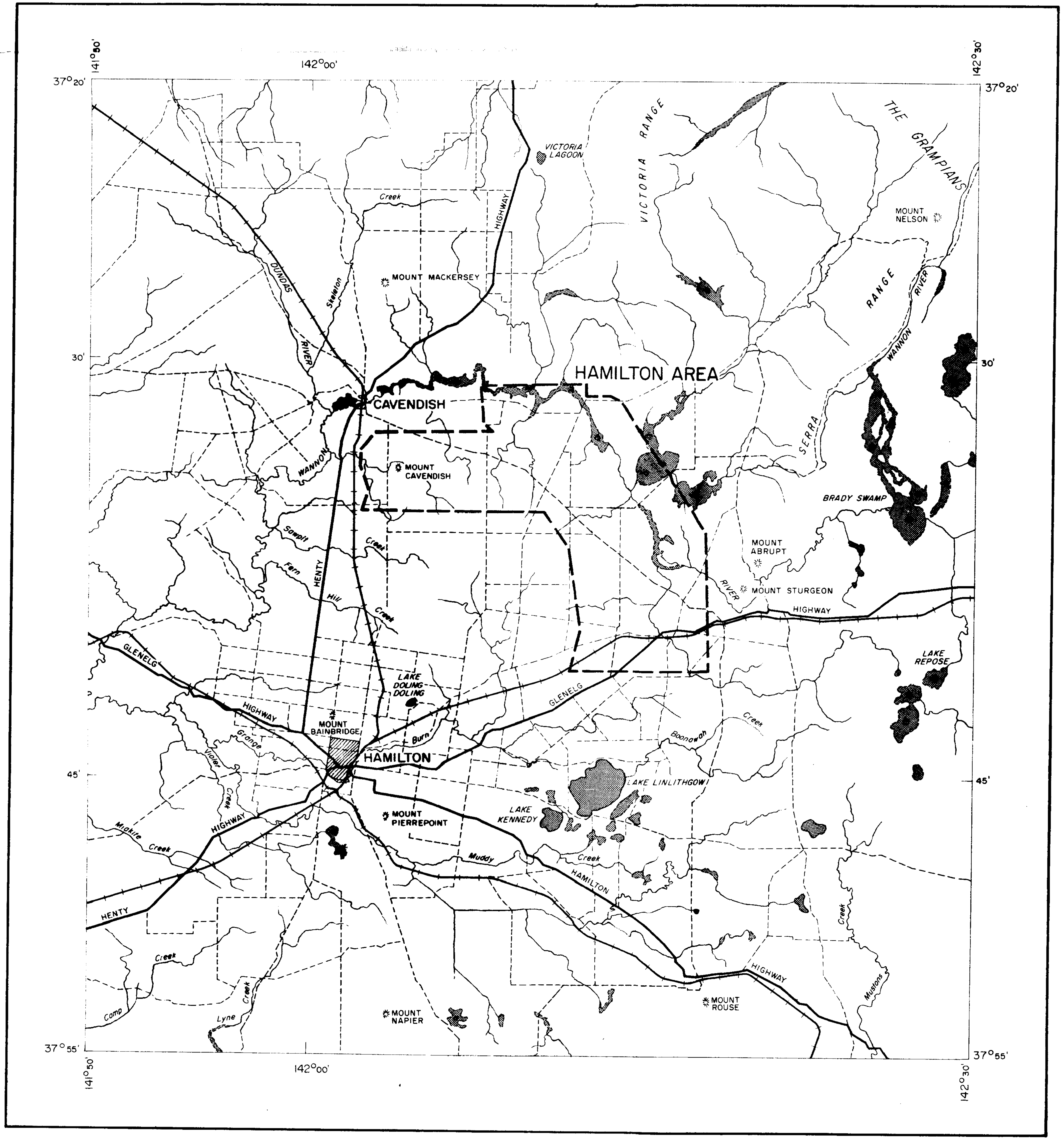
Personnel

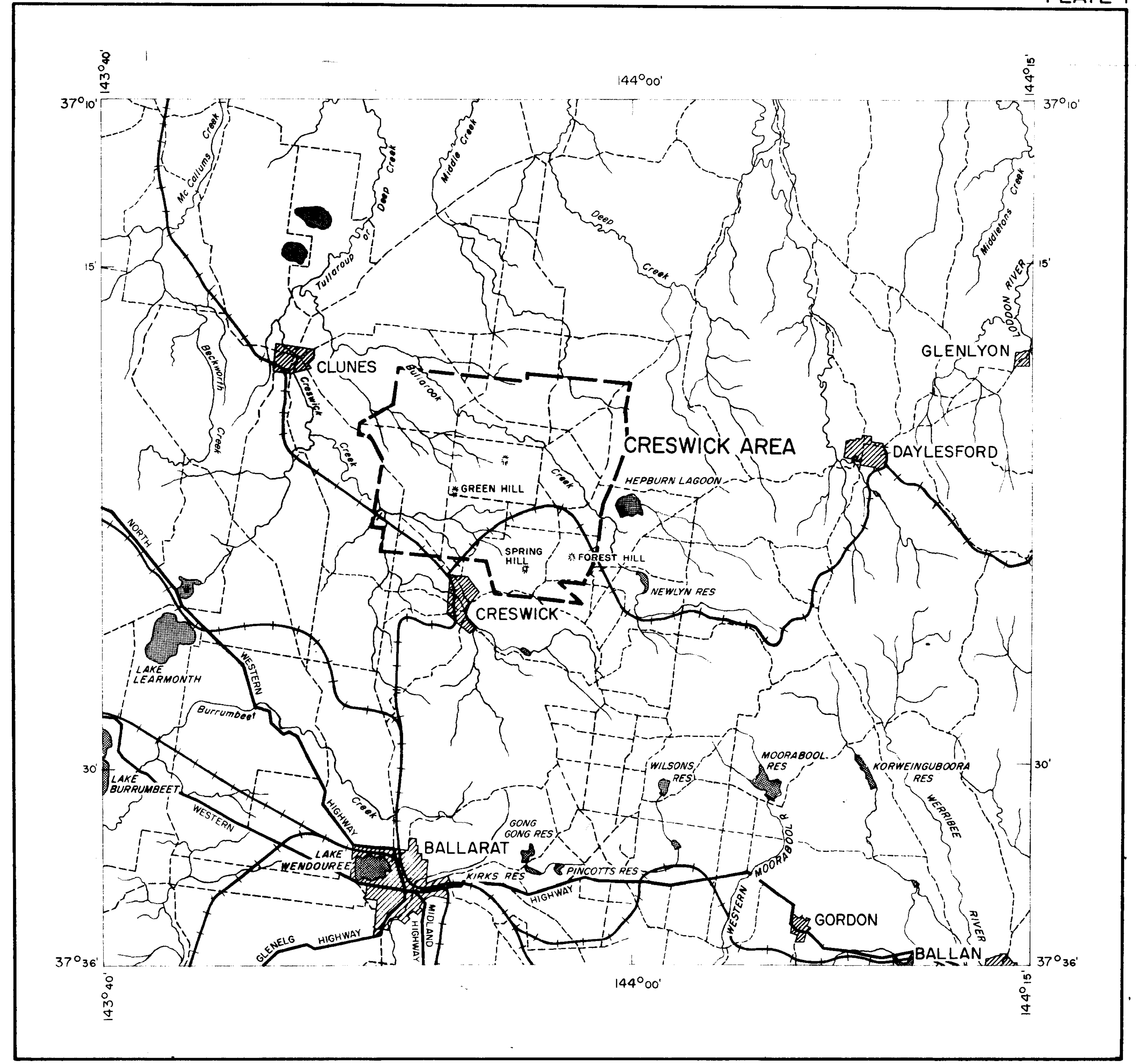
Personnel engaged in the survey were:

BMR - B. A. Dockery, E. P. Shelley, R. A. Gerdes, W. R. D. Buckley, L. M. O'Toole, P. Evans, B. M. Tregellas, G. Sauerberg, B. J. Mayfield

TAA - First Officer J. Lord

PLATE I

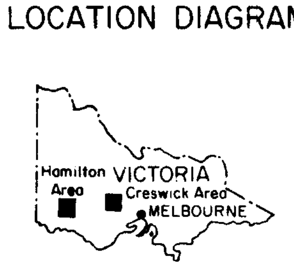


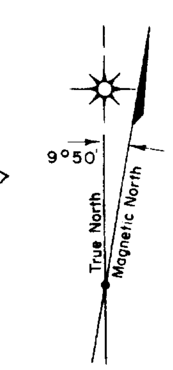


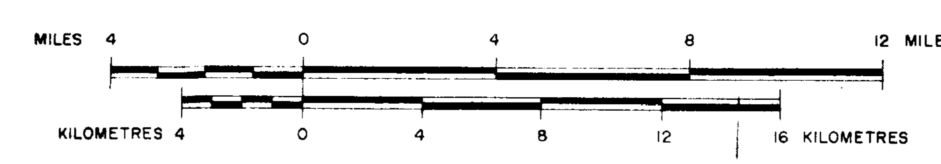
DETAILED AEROMAGNETIC SURVEY, WESTERN VICTORIA, 1966

LOCALITY MAP

LOCATION DIAGRAM







TOPOGRAPHICAL LEGEND

- HIGHWAY
- ROAD OR TRACK
- RAILWAY
- RIVER OR CREEK
- LAKE
- SWAMP
- DAM
- BOUNDARY OF SURVEY AREA
- HILL FEATURE
- TOWN

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

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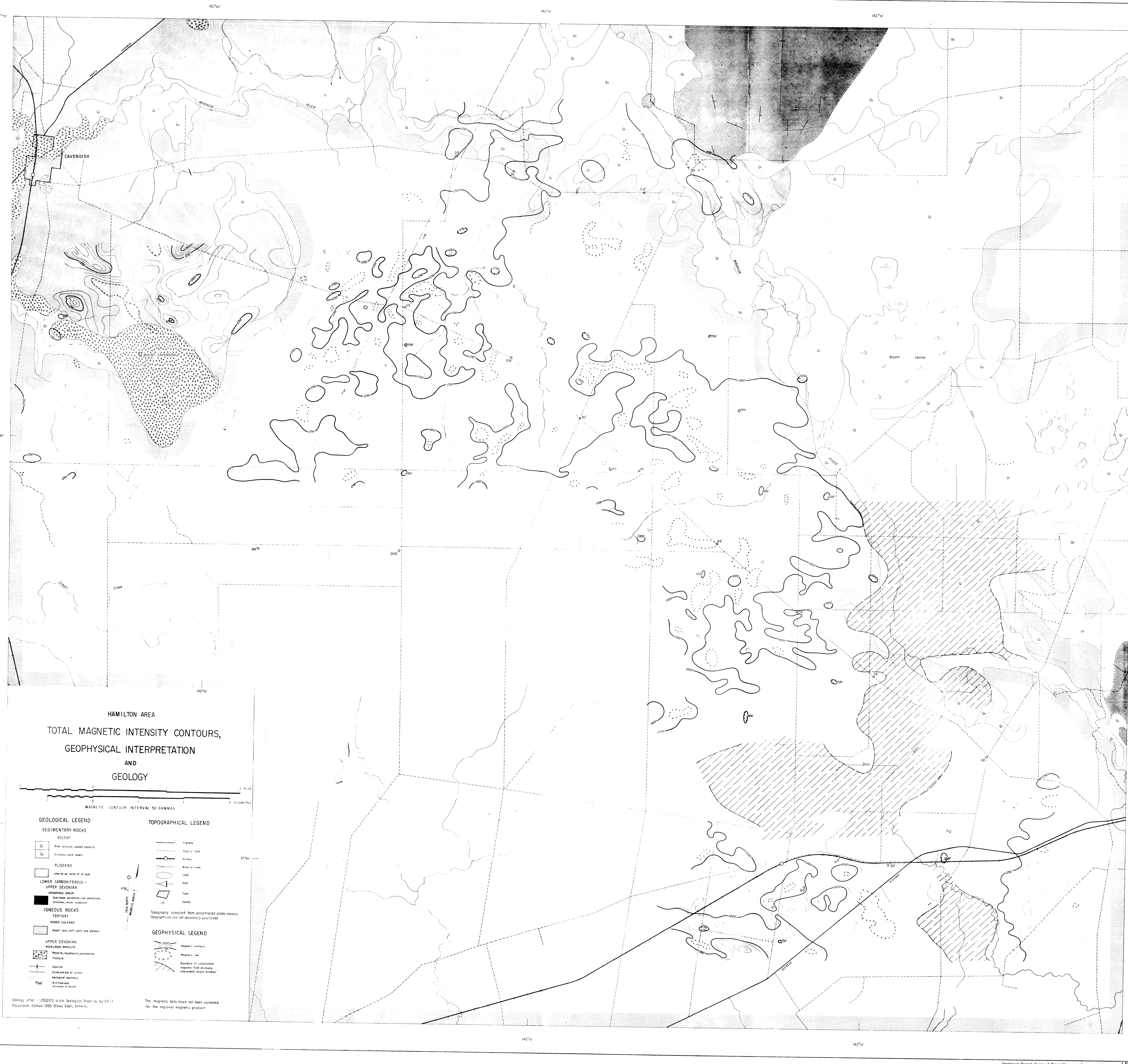
PLATE 4



Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics J 54/B1-21

TO ACCOMPANY RECORD No. 1967/44