COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1968 / 147

Western Victoria Detailed Aeromagnetic Survey, 1968

by

R.A. Gerdes

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SUMMARY

The survey was the third of a series of three surveys carried out between 1966 and 1968 in conjunction with the Geological Survey of Victoria, who is concerned with the exploration of brown coal in western Victoria. The 1:63,360 map areas of Beeac, Colac, and Cobden were covered with east-west flight lines a fifth of a mile apart with the aircraft at a constant ground clearance of 400 feet.

Brown coals of the Eastern View Coal Measures (Moorarbool Viaduct Formation) have been mined by open cut on the northern flanks of the Otway Ranges at Deans Marsh and Wensley Bray. Available drill hole data indicate that inferior brown coal occurs as small discontinous seams 1 to 4ft thick, with occasional thicker seams, at Deans Marsh and Wensley Bray. Parts of the western Victorian brown coal deposits are covered by basalt flows of New Volcanics. It is therefore only possible to mine the brown coal economically in areas where the basalt is thin, weathered, or absent. The aim of the survey was to map such areas by the use of an airborne magnetometer.

Interpreted magnetic zones are used to delineate areas of Cretaceous and Tertiary sediments and to differentiate between areas of thin or weathered basalt and areas of thicker basalt. Points of eruption and possible basalt-filled river valleys have been outlined.

The zoned magnetic data are discussed with respect to their relevance to basalt cover and thickness. Drilling to test the validity of the interpretation is recommended in some places.

1. INTRODUCTION

This survey is the third of three undertaken by the Bureau of Mineral Resources(BMR) in western Victoria at the request of the Geological Survey of Victoria to try to predict areas of thin, non-existent, or decomposed basalt cover, which can be subsequently drilled for brown coal. Most of the brown coal areas are overlain by basalt and mining is probably uneconomic except where the basalt is decomposed or sufficiently thin.

In 1967, BMR surveyed the SKIPTON, LISMORE, and ROKEWOOD 1:63,360 areas, and in conjunction with the Geological Survey of Victoria selected the BEEAC, COLAC, and COBDEN 1:63,360 areas for the 1968 survey. These areas are situated to the north, east, and west of the town of Colac, and cover a total area of 1428 square miles. The aeromagnetic survey was carried out from March to May 1968, using the Cessna 180 VH-GEO fitted with a proton precession magnetometer, MNS-1 mounted in a towed bird. Operational details are recorded in Appendix 2.

2. GEOLOGY

The greater part of the survey area lies on the northern margins of the late Mesozoic Otway Basin, which includes south-western Victoria and south-eastern South Australia. For a detailed discussion of the basin, the reader is referred to Leslie (1965), Reynolds (1967), and in particular to BMR (1966).

Sedimentary rocks

Although no Palaeozoic rocks crop out in the survey area, Ordovician slates, sandstones, and sub-greywackes crop out to the north, in the vicinity of Ballarat.

On borehole evidence these Palaeozoic rocks continue under the post-Palaeozoic sediments of the survey area.

The oldest outcropping unit in the survey area, the Lower Cretaceous Otway Group (Unit M, BMR, 1966) crops out in COLAC, particularly in the south-eastern portion, and underlies the greater part of COBDEN and possibly part of BEEAC. This unit is a thick, fairly uniform succession of arkosic, feldspathic, and tuffaceous sandstones, chloritic mudstones, and bituminous coals (Leslie, 1965; BMR, 1966).

The beginning of the Tertiary deposition was marked by a marine transgression and a change to widespread, uniform sedimentation. While most of this sedimentation was marine there were areas of fresh-water deposition, as evidenced by localised deposits of brown coal. Brown coals of the Eastern View Coal Measures have been recorded from the northern flanks of the Otway Ranges at Deans Marsh and Wensley Bray in COLAC, and further to the east in the Anglesea area, at Wensleydale, Benwerrin, and Murroon (Thomas and Baragwanath, 1950).

Pleistocene to Recent deposits are mainly terrestrial alluviums, silts, clays, sands, gravels, and peats occuring particularly in the region north-north-east of Colac.

Igneous rocks

Much of the Victorian Cainozoic is marked by basic igneous activity, the Older and New Volcanics. The Older Volcanics range in age from Eocene to Oligocene (60 to 23 million years), with the maximum activity in the Eocene (Robertson, 1966). The Newer Volcanics range in age from Pliocene to Recent (Edwards, 1938). Although both are olivine basalts, the Older Volcanics are commonly intrusive, whereas the Newer Volcanics are normally extrusive and tend to be more tholeiitic in composition.

The Older Volcanics are largely restricted to the east of Melbourne, but small outcrops occur in the south-eastern corner of COLAC, and basalts correlated with the Older Volcanics were intersected at depth in the Cressy No. 1, Koort-Koort-Nong No. 3 and the Birregurra No. 1 bores.

The Newer Volcanics form a sequence of flows, with a maximum total thickness of 200 ft, covering much of BEEAC and the northern parts of COLAC and COBDEN. They have been further sub-divided by Bock et al (1966) into an early series of broad flows or basalt plains (Earlier New Volcanics) and a later series consisting of olivine basalt (Later Newer Volcanics) stony rises and valley flows and pyroclastics, comprising basaltic tuff, scoria, cinders, ash, and lapillistic and scoriaceous basalt.

The basalt was derived from numerous lava or scoria cones, now visible as low hills up to several hundred feet high. Local subsidence associated with late stage volcanic activity has occurred as tuffrings, maars, and calderas. These subsidence structures are represented as circular lakes in COBDEN and COLAC and are commonly associated with volcanic cones within the caldera structure.

3. PREVIOUS GEOPHYSICAL EXPLORATION

Apart from two BMR airborne magnetic surveys, little if any geophysical work appears to have been done over the Western Plains basalts.

Oil exploration companies have carried out a number of reflection seismic surveys west and south-west of the survey area (BMR, 1966) and a BMR refraction seismic traverse (Branson, in prep.) is terminated several miles east of BEEAC. Technical difficulties arising from the basalt cover and the thinner Mesozoic-Cainozoic section, probably explain the absence of seismic work in the survey area.

In the first of the three aeromagnetic surveys of the area (Dockery, 1967) it was found that the magnetic field over the basalt was extremely disturbed, and the total magnetic intensity appeared to vary randomly from point to point over the basalt, except over extinct volcanoes. Although there was little relation between basalt thickness and total magnetic intensity, the anomaly amplitudes tended to be less in areas of thin basalt cover. Dockery however concluded that a detailed aeromagnetic survey could detect 'windows' in the basalt of the order of one mile or more in diameter when the underlying rocks are only weakly magnetic. He suggested that boundaries of these windows could be determined by inspection of the magnetic profiles, because the intensity normally changed gradually over a distance of about half a mile across the boundary.

During the 1967 BMR survey (Gerdes, 1968), a method of zoning the magnetic profiles was developed. This method was again adopted for interpretation of the data which form the subject of this Record (see Appendix 1).

4. RESULTS

The interpreted results of the three 1:63,360 areas covered by the survey are displayed in Plates 2, 3, and 4 and are treated separately in this section. The significance of the lettered zones shown in the plates is discussed in Appendix 1.

Some interference with the airborne magnetometer and consequent loss of data was caused by electric transmission lines which cross the survey area in places. These are also displayed in the plates.

BEEAC (Plate 2)

The basalt flows of the Earlier Newer Volcanics cover the northern and western portion of BEEAC. The points of eruption are located at Mount Rebecca, Gows Hill, and Mount Pleasant. In each case the associated magnetic field is very disturbed. Similar areas of intense disturbance were detected among the lava flows and pyroclastic deposits of the Later Newer Volcanics situated in the south-western corner of BEEAC, and at Mount Hesse and The Cap.

The data from the drill holes Nos. 1 to 5 (Appendix 3) show that the basalt of the Later Newer Volcanics is thicker around Warrion Hill (190 ft) and thins away to the north from this hill, in an area of Zone C.

The only mapped outcrops of Tertiary sediments in BEEAC, namely the Moorarbool Viaduct Formation and the Heytesbury Group, which crop out along the Yarrowee River, east of Shelford, are outlined by a Zone A, which extends northwards into ROKEWOOD. The boundary of this Zone A in BEEAC is displaced approximately half a mile east of the geological one. Another Zone A situated near Ellingerrin Homestead at the junction of Warrambine Creek and Five Mile Creek is mapped as basalt, but Currey (1964) showed sands and clays of the Moorarbool Viaduct Formation in this area.

In the eastern part of BEEAC, areas of Zone B are situated east of the road from Ombersley to Gows Hill. These represent areas of Tertiary sediments covered by a veneer of Earlier Newer Volcanics. The isolated areas of Zone C might represent patches of less weathered basalt, whereas the larger Zones C are possibly thicker basalt flows which have infilled the pre-basalt drainage surface.

Currey (1964) outlined the pre-basalt river courses of the Yarrowee River (Leigh River), Warrambine Creek, and Barwon River. He suggested that the old course of the Yarrowee River paralleled the present one from Shelford via Inverleigh (outside the area) to Winchelsea, where it joined the pre-basalt course of the Barwon River at Lake Modewarre Gap to the east of Winchelsea. The isolated Zones C west of Shelford and the larger Zones C situated east of Ellingerrin Homestead and at Rivernook Homestead on the Barwon River may indicate the old course of the Yarrowee River.

Currey similarly suggested that Warrambine Creek flowed east, parallel to and between its present course and Mia Mia Creek, near Wingeel railway station. Its position is possibly indicated by a west-trending Zone C which runs south of and parallel to the present creek towards Ellingerrin Homestead.

The Zone C which trends eastwards from Mount Hesse across the northern portion of Lake Murdeduke to Rivernook Homestead may represent another pre-basalt drainage system.

In the western part of BEEAC, Zones A and B form a continuation northwards of a Zone A from COLAC, which extends over Lake Colac and Lough Calvert towards Beeac. The Zone A in BEEAC extends from Beeac township over Lake Beeac and Lake Cundara in the west, and Lough Calvert region as far north as Eurack. This block of zones occurs over Quaternary sediments, which may overlie the Moorarbool Viaduct Formation (Heytesbury Group).

The Zone A situated southwest of Cressy, near Martins Lake, corresponds to the area of Moorarbool Viaduct Formation which trends southwards from Cressy as shown by Currey (1964, Fig. 7). No Newer Volcanics were present in the Cressy No. 1 drill hole, but 115 ft of decomposed Older Volcanics were detected beneath 601 ft of Tertiary sediments. This supports Currey, and suggests that some of the anomalies in the Zone B south of Cressy were produced by the Older Volcanics at depth.

The Zones A and associated Zones B situated over water and on the northern and southern sides of Lake Corangamite occur over Quaternary sediments. These Zones A may outline Tertiary sediments overlain by Quaternary sediments, which relate to sediments of the Heytesbury Group found west of this area on the western edge of Lake Corangamite in CORANGAMITE (Bock et al, 1966). The Zones B probably represent a thin weathered veneer of basalt overlain by Quaternary sediments resting on the Heytesbury Group.

The Zone C which extends to the east from Lake Corangamite to the centre of BEEAC may represent a pre-basalt drainage system which possibly extends to the south of Mount Hesse.

The Zones B situated on the northern and north-eastern sides of Mount Rebecca occur over a series of isolated Quaternary deposits, and probably represent weathered basalt at depth.

The tentative Zones B situated on either side of the Hamilton Highway between Poorneet and Wingeel may represent magnetic 'lows' associated with anomalies in Zone C, or an area of weathered basalt.

<u>COLAC</u> (Plate 3)

This area, which is predominantly Zone A, is mostly covered by non-magnetic Tertiary and Cretaceous sediments. The boundary of Zone A shows a reasonable correlation with the geology.

In the northern and north-eastern part of COLAC, the Zones B situated north of the Princess Highway between Armytage and Warncoort railway stations and the larger one situated in the areas south of the high-tension power line between Winchelsea and Armytage railway station possibly represent a gradual thickening of the New Volcanics northwards from their southern edge. The Zone C situated on the northern central boundary of the area and the isolated Zone C situated two miles south-west of Winchelsea probably represent areas of fresher and thicker Newer Volcanics. The latter may also represent an unmapped point of eruption.

The Zones B and Zones C in the north-west corner of the area occur over the basalts and pyroclastic deposits of the Later Newer Volcanics associated with the Red Rock and Robertsons Hill points of eruption, and over areas of Tertiary and Quaternary deposits. The area of Tertiary sediments (Moorarbool Viaduct Formation) situated north of Robertsons Hill was not resolved by the magnetic results. The Quaternary sediments overlying the Later Newer Volcanics near Robertsons Hill were not differentiated, but were included with the Zones B and C. The Zones B in this region probably represent areas of thin or weathered basalt. Drill hole No. 6 (see Appendix 3) indicated that 63 ft of basalt of the Later Newer Volcanics occurred in the Zone B near Balintore. Zone C probably represents recent pryoclastics and lavas associated with the points of eruption. The Red Rock maar or tuffring, and Robertsons Hill, a multiple scoria dome, are both associated with intense magnetic disturbance which decreases in magnitude southwards from Robertsons Hill. The isolated Zone B situated east of Larpent railway station may represent an area of weathered basalt not shown in the geology.

The Earlier Newer Volcanics situated north-east of Colac and trending east from Quarry Hill to Warncoort railway stations appear to be less extensive than shown by the mapped geology. The Zones B and Zone C occur along the northern and south-western edge of the inlier of basalt of the Earlier Newer Volcanics and the Moorarbool Viaduct Formation. Gill (1964) states that, "at Colac, a fault at the southern end of Lake Colac brings up the Cretaceous rocks, and has also uplifted an ancient river bed covered with basalt; a volcano is also sited there,--of possibly Lower Pleistocene age", and this fault "is the primary cause of the formation of Lake Colac". This would explain the reason for the shape and position of the inliers of Earlier Newer Volcanics in this area.

The east-west trending area of Earlier Newer Volcanics situated south of Warncoort railway station was only resolved by Zones B and C south of the high-tension power line. The two Zones B situated south-east of Birregurra occurred over both Tertiary and Quaternary sediments. No Newer Volcanics were detected in the Birregurra No. 1 drill hole, 1 mile to the north-west, but 33 ft of decomposed Older Volcanics was struck at 1022 ft. These Zones B indicate either that some Newer Basalt exists beneath the Quaternary sediments or that a local area of fresh Older Basalt exists at depth.

The Zone B situated west of Kawarren coincides with an outcrop of Older Volcanics. This zone extends beyond the basalt outcrop. The Zone B situated south-east of Kawarren could be associated with an area of unmapped Older Volcanics.

The Zone B situated around Yeodene consisted of broad anomalies with amplitudes of up to 50 gammas, which may be produced by fresh Older Volcanics at depth. No Older Volcanics were detected in drill holes Nos. 10 and 12, (see Appendix 3) which penetrated 1186 and 175 ft of sediments respectively, but drill hole No. 10 penetrated a 1-ft ironstone band, and drill hole No. 12 penetrated ironstone bands 1 and 2½ ft thick at 44 and 55½ ft respectively. Other drill holes in COLAC (Nos. 11, 24, and others in the Wensley Bray Open Cut area)

intersected bands of ironstone, but no similar anomalies were produced, and it seems unlikely that the ironstones are the source of the anomalies.

COBDEN (Plate 4)

In this area the Tertiary sediments of the Wangerrip and Heytesbury Groups are outlined by Zone A. Some small isolated Zones B situated in the south-east corner of the area, occur within the main region of Zone A, and may represent areas of unmapped Older Volcanics.

The large Zone A which stretches northwards from Pirron Yalloak to Herring Point includes the present extent of Lake Corangamite and its associated Quaternary sediments. This zone represents an area of non-magnetic sediments, both Tertiary and Quaternary, and shows that no basalt occurs under the lake. This suggests that the Moorarbool Viaduct Formation extends northwards under the lake from Pirron Yalloak, and possibly connects with sediments of the Heytesbury Group that occur on the north-western side of Lake Corangamite in CORANGAMITE (Bock et al, 1966).

There is a good general agreement between the boundary between Zones A and B and the mapped boundary between the Tertiary sediments and the Newer Volcanics, particularly between Tandarook and just west of Pirron Yalloak and also along Curdies Creek from Glenfyne (outside area) to due east of Elingamite. The Zone B at this boundary possibly represents a thin un-weathered veneer of Newer Volcanics resting on Tertiary sediments.

The Tertiary sediments situated in the area south-east of Cobden, between Jancourt and Tandarook are represented by a Zone C, except for several areas of Zone B which occur over the extremities of Tertiary sediments. These small Zones B situated over a basalt-filled river valley in the Curdies Creek system may be either a magnetic 'low' associated with the intense anomalies nearby, or an area of thin weathered basalt. Other than these Zones B occurring over the Gellibrand Marl the rest of the deposit is undefined, as the area is dominated by a Zone C. This indicates that the Earlier Newer Volcanics may extend southwards to the outlier of Later New Volcanics.

The two inliers of the Heytesbury Group at Bostock Creek and at Tandarook are outlined by Zones B. The later Zone B is tentative, as it may represent a magnetic 'low' associated with the more magnetic zones, and these inliers are probably too small in area to be resolved by the magnetics.

The Port Campbell Limestone (Heytesbury Group) cropping out south-east of Curdies Creek and north-west of Cobrico are situated in areas of Zone A. The Zone A north-west of Cobrico extends northwards from Cobrico Swamp to north of Evans Hill, and incorporates areas of Earlier and Later Newer Volcanics. The Zone A and Zone B situated south of Cobrico Swamp indicate that the Port Campbell Limestone underlies a thin veneer of Earlier Newer Volcanics and suggest that the pyroclastics of the Later Newer Volcanics on the northern and western side of the Evans Hill and around Cobrico Swamp are non-magnetic.

The remaining Zones B situated over basalt in COBDEN represent regions of thin and/or weathered basalt. These zones occur in the following areas: east-west from Herring Point on Lake Corangamite; north-west of Pomborneit East; south-east of Nalangil; in the region between Pirron Yalloak, Carpendeit, and Stoneyford; around Purrumbete South towards Burnips Creek; and between Koallah and Lake Purrumbete. In the last region, the three Zones B represent either thin weathered basalt and pyroclastics of the Later Newer Volcanics resting on Tertiary sediments or magnetic 'lows' associated with zones of higher magnitude.

The pyroclastic deposits and basalt flows of the Later Newer Volcanics generally correlate with a Zone C. The pyroclastics in the north-eastern corner of COBDEN, between The Basins and Red Rock, are included in a Zone C. Vaughan Island, a scoria dome (Ollier & Joyce, 1964), correlated with an anomaly of less than 50 gammas, slightly displaced to the west of the dome. The anomaly associated with The Basins, a multiple scoria dome with two wide oval crater lakes (ibid), was less than 20 gammas (i.e. a Zone B). The southern extremity of the pyroclastics at The Basins was included with a Zone A. The two areas of pyroclastics outcropping to the north-west of The Basins were represented by anomalies of less than 50 gammas, which are included at the western extremity of a Zone B. This suggests that these pyroclastic deposits are less magnetic than those at Red Rock.

Probable volcanic centres are also shown in Plate 4. Mount Porndon, Mount Leura, Bostock Hill, Evans Hill, Lake Purrumbete, and Lake Elingamite are examples of such centres.

A number of Zones C to the east of Cobden may be caused by basalt flows originating from Mount Leura and the scoria dome near Tilinda Homestead. The outlier of Later Newer Volcanics between Tandarook and Jancourt is also associated with a Zone C, and probably indicates flows of basaltic material associated with the scoria domes and craters in this area.

5. CONCLUSIONS

The positions of the magnetic zones show a general agreement with the geological mapping by the Geological Survey of Victoria. In particular, Zone A delineates known areas of Cretaceous and Tertiary sediments in the southern half of COBDEN and COLAC and in the north-eastern corner of BEEAC.

Zone B delineates possible areas of thin and/or weathered basalt overlying Tertiary sediments in the basalt plains. Some Zones B may represent areas of unweathered Older Volcanics at depth (e.g. Cressy No. 1 drill hole) or magnetic 'low' associated with higher-order zones.

The Zones B situated inside the main expanse of Zone A indicate one or more of the following possibilities: (a) thin weathered veneers of basalt overlying the Tertiary sediments at or near the Zone A boundary; (b) a known outcrop of Older Volcanics; (c) areas of possible magnetic ironstones or Older Volcanics at depth.

Zones C occur in regions of pyroclastic deposits and basalt flows of the Earlier and Later Newer Volcanics and probably represent areas of thicker basalt than that of Zone B. Some correspond to basalt-filled river valleys.

The Zones B and C, situated over non-magnetic Quaternary sediments, are produced by the underlying basalts of the Newer Volcanics.

The correlation between the geological boundaries and magnetic zones is generally good, but some discrepancies, up to three-quarters of a mile in places, are associated with errors in base mapping and the subjective element in the interpretation of the data. Larger discrepancies indicate that the magnetic results and the geological mapping are not in agreement.

The validity of the magnetic interpretation can best be tested by drilling in areas where Zones A or B encroach upon outcropping basalt or Quaternary sediments in as much as these might overly basalt.

Six possible sites are tabulated below:

1:63,360 area	Target Zone	Location
BEEAC	A	Southwest of Cressy
BEEAC	A	At the junction of Warrambine and Five Mile Creek near Ellengerrin Homestead
BEEAC	A	Occurring over Quaternary sediments extending northwards over Lake Colac to Lake Beeac and as far as Watch Hill
COLAC	A	East of Lake Colac
COLAC	B	South-west of Winchelsea
COBDEN	A	In the north-west corner of COBDEN

It is not implied that these sites have any special significance in the search for brown coal.

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APPENDIX 1

INTERPRETATION METHODS

The interpretation is bases on the ideas outlined by Dockery (1967) and Gerdes (1968).

Because of all the unknown variables associated with the basalt and the resulting complexity of the total magnetic field, a purely quantitative method for estimating basalt thickness could not be used. A list of the unknown variables connected with the basalt is listed below:

(1) Variable number of flows.

(2) Variable thickness and distribution of flows. The thickness is not constant in any one flow, either across or along its length.

(3) Variable composition in any one flow, both laterally and vertically.

(4) Remanent magnetisation is variable in magnitude and direction throughout the basalts flows. There are six known periods of reversed magnetisation within the last 4 million years.

A qualitative method, based on a zoning of the survey area in terms of the character and amplitude of the magnetic anomalies, was adopted. The magnetometer charts were smoothed and zoned initially on anomaly amplitude without taking account of any linearity in the data. Six zones were adopted, viz.

Zone	Amplitude (gammas)
1	0-10
2	10-20
3	20-50
4	50-100
5	100-200
6	greater than 200

The zone boundaries were transferred to the plotted flight lines on the control photography to an accuracy of ± 300 ft.

A study of the disposition of these six zones indicated that they could be further reduced to three groups or major zones, designated A, B, and C in this Record. Major zone A is predominantly zone 1 with scattered areas zoned as 2 and 3, whereas major zone B is predominantly zones 2 and 3 with relatively minor areas zoned as 1 and 4. Major zone C includes the most magnetically disturbed areas initially zoned 4, 5, and 6, although small areas of zones 1, 2, and 3 are included.

Table 1 (extracted from Gerdes, 1968) displays a possible interpretation of Zones A, B, and C when related to drilling data.

Zone A, which delineates the areas interpreted as free of basalt cover, shows a close correlation with the known geology. The boundary of this zone is marked by Zones B and C. It is suggested that Zone C represents areas of relatively thick basalt and Zone B represents areas of thin and/or weathered basalt.

Where the disposition of magnetic anomalies, and in some places the topography, suggest a centre of vulcanicity, these have been shown on the plates as locations of probable volcanic necks or cones.

TABLE 1

Zone	Number of drill hole groups in zone	Maximum range of basalt thickness (feet)	Probable range of basalt thickness (feet)	Maximum range of basement depth (feet)	Probable range of basement depth (feet)	Possible interpretation
A	2	Zero	Zero	0 to 90	15 to 60	Tertiary sediments overlying Ord. sediments and Post-Ord. granite
B	16	0 to 65	30 to 60	10 to 130	65 to 90	Thin and/or weathered basalt
C	24	30 to 370	60 to 210	60 to 390	75 to 230	Relatively thick basalt

APPENDIX 2

OPERATIONAL DETAILS

Personnel

BMR	R.A. Gerdes	:	Party Leader
	R.D. Beattie	:	Geophysicist
	P. Moffat	:	Drafting Assistant
	R. Curtis - Nuthall	:	Senior Technician(Radio)
	B.M. Tregellas	:	Geophysical Assistant
T.A.A.	First Officer G. E. Brown	:	Pilot

Survey Specifications

Survey altitude	:	Normally 400 ft a.g.l. was increased to 600 ft at latitude 38°23', and over Otways Ranges 1000 ft a.g.l.
Line spacing	:	1/5 th mile
Line orientation	:	East - west
Area surveyed	:	1428 square miles
Navigation control	:	Aerial photographs (scale 1:40;000)
Survey commenced	:	13th March 1968
Survey finished	:	15th May 1968

Equipment

Aircraft	:	Cessna 180 VH-GEO
Magnetometers (a) airborne	:	MNS 1 (P) BMR proton precession type with CTP 1 power/cycling unit. Towed bird installation suspended by cable 30 ft below aircraft outputs to Moseley 2-channel recorder.
(b) ground station	:	MNS 1 with Esterline-Angus recorder.

Equipment

Camera	:	Modified Vinten Frame, 35-mm wide-angle (186° field of view)
Radio altimeter	:	AN/APN-1. Operated as aid to altitude control. No record taken.
Magnetometer chart speed	:	Moseley Recorder; 2 inches/min.
	:	Esterline-Angus 6 inches/hour.
Magnetometer cycle time MNS 1 (P)	:	1.0 second
MNS 1	:	30 seconds
Recorder Sensitivity	:	1st channel : 100 gammas f.s.d.
	:	2nd channel : 1000 gammas f.s.d.

Flight line control over Lake Corangamite

The first set of flight lines over Lake Corangamite were extrapolated from known plotted points on the eastern side of the lake. An additional series of flight lines were flown across the lake and extrapolated between known plotted points on each side of the lake for each flight line. This gave better zonal accuracy over the water.

APPENDIX 3

SUMMARY OF DRILL HOLE DATA IN THE SURVEY AREA

Information concerning shallow drillings for water and clay deposits and deeper boreholes were made available by the Victorian Department of Mines in their Annual Reports, Drilling Reports, and Boring Records. The positions of relevant drill holes have been plotted in Plates, 2, 3, and 4. The data of the individual drill holes and groups of drill holes are tabulated in Table 2. The data selected include the thickness and depth to base of the Older and Newer Volcanics; thickness and age of sediments; basement depth and age if known; total depth of drill hole; and the state of basalt encountered where available.

BEEAC

Brown coal was encountered in Cunadare No. 1 drill hole; the seam was 6 ft thick at 117 ft below ground; and at Doroq No. 2 drill hole, which is situated three miles east of BEEAC in the Anglesea Embayment (Leslie, 1965) where fine seams were encountered at five levels in the section.

COBDEN

Brown coal was encountered in Coradjil No. 1 drill hole; the seam was 1 ft thick at 533 ft below ground.

COLAC

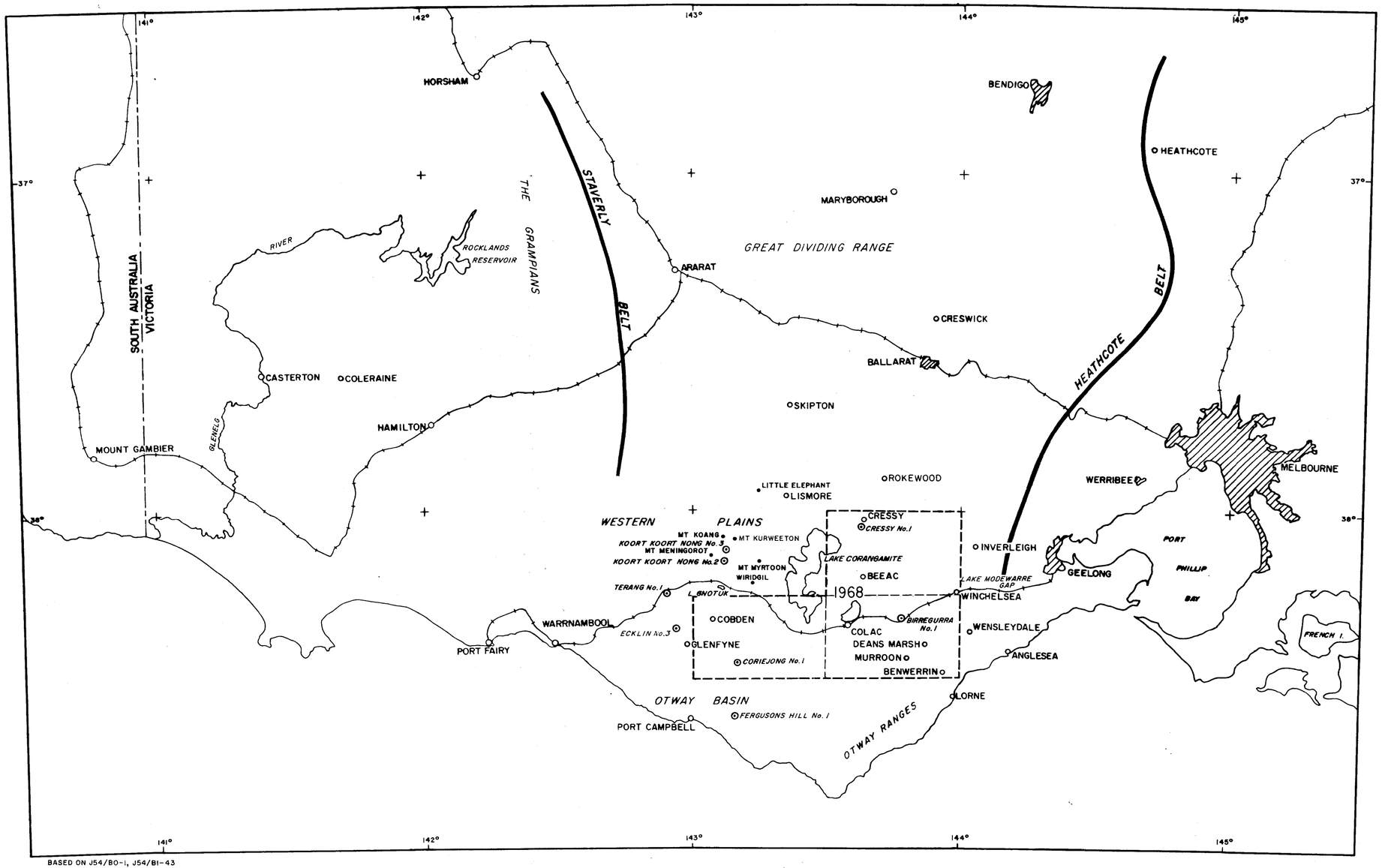
Brown coal has been mined at the Deans Marsh and Wensley Bray Open Cut Mines. Extensive shallow drilling has been done, and a number of small lenses of inferior brown coal 1 to 4 ft thick have been detected in areas out-lined by drill holes (see Table 2) which are as follows; No. 13; Nos. 15 to 18 inclusive, situated south of Murroon; Nos. 20 to 29 inclusive, situated in an area which stretches from Deans Marsh, through Yan Yan Gant Homestead, Bambra, and to Wensley Bray Open Cut. The only thick developments of an inferior brown coal was 41 to 51 ft at 100 ft depth approximately at Deans Marsh (drill hole No. 20), and 24 ft at a depth of 62 ft at Wensley Bray Open Cut (drill hole No. 29). Two deep drill holes, Bambra No. 49 and drill hole (19), indicated no brown coal, but the latter hole had carbonaceous shales at various depths.

Table 2
Selected Drill Hole and Water Borehole Data relevant to BEEAC, COLAC, and COBDEN 1:63,360 map areas

Number	Parish or Special Drill Hole	Newer Volcanics Thickness (feet)	Newer Volcanics Depth to Base (feet)	Older Volcanics Thickness (feet)	Older Volcanics Depth to Base (feet)	Sediments Thickness (feet)	Sediments Age	Basement Depth (feet)	Basement Age	Total Depth of Hole (feet)	State of Basalt	Remarks
BEEAC												
	Cressy No 1	Nil	Nil	115	601	98 388	Quart Tert	610	Ordovician	668	Decomposed	
	Cundare No 1	117	117	Nil	Nil	1194	Tert	1317	Otways Group (Cret?)	1507	Fresh	Brown coal 6ft at 117ft B.G.L.
1	Cundare (4)	110	110	Unknown		Unknown	Tert		Unknown	160	Fresh	
2	Cundare (5)	138	138	Unknown		Unknown	Tert		Unknown	185	Fresh	
3	Dreeite (5)	166	167	Unknown		Unknown	Tert		Unknown	195	Fresh	Water in vessicular basalt at 72 to 76ft B.G.L.
4	Cundare (3)	192	192	Unknown		Unknown	Tert		Unknown	395	Fresh	
5	Dreeite (2)	60	61	Unknown		Unknown	Tert		Unknown	75	Fresh	
COLAC												
	Birregurra No 1	Nil	Nil	33	1055	1030	Tert	1063	Otways Group (Cret?)	1103	Decomposed	Minor coal at 1006ft B.G.L.
	Bambra No 49	Nil	Nil	Unknown		greater than 648	Tert		Unknown	648	–	
6	Warrion (5)	63	66	Nil	Nil	1636	Tert	1636	Otways Group (Cret?)	1652	Fresh	
7	Nalangil (4)	Nil	Nil	Unknown		Unknown	Tert		Unknown	32	–	No basalt – agrees with geology
8	Nalangil (3)	Nil	Nil	Unknown		Unknown	Tert		Unknown	32	–	No basalt – agrees with geology
9	Nalangil (2)	Nil	Nil	Unknown		Unknown	Tert		Unknown	22	–	No basalt – agrees with geology
10	Yeo (5)	Nil	Nil	Nil	Nil	1186	Tert (?)		Unknown	1186	–	Ironstone 1ft at 15ft. Brown coal 1 & 2ft at 178 & 724ft B.G.L. Water struck at 737ft
11	Yeo (1)	Nil	Nil	Nil	Nil	103	Tert		Unknown	103	–	Ironstone at 15ft. Brackish water at 41ft
12	Yeo (3)	Nil	Nil	Nil	Nil	175	Tert		Unknown	175	–	Ironstone 1 and 2½ft at 44 and 55½ft resp. Brackish water at 155ft
13	Gerangamete (6)	Nil	Nil	Nil	Nil	527	Tert		Unknown	527	–	Brown Coal 1ft at 372 and 387ft B.G.L. resp
14	Murroon (6)	Nil	Nil	Nil	Nil	256	Tert		Unknown	236	–	Brackish water at 7ft
15	Murroon (11)	Nil	Nil	Nil	Nil	400	Tert		Unknown	400	–	Brown coal 2ft at 332ft
16	Murroon (1)	Nil	Nil	Nil	Nil	186	Tert		Unknown	186	–	Brown coal 8ft at 164ft
17	Murroon (2)	Nil	Nil	Nil	Nil	156	Tert		Unknown	156	–	Brown coal 5ft at 130ft
18	Murroon (8)	Nil	Nil	Nil	Nil	500	Tert		Unknown	500	–	Brown coal 2 and 3ft at 148 and 300ft resp
19	Bambra (1)	Nil	Nil	Nil	Nil	1850	Tert and Cret?		Unknown	1850	–	No coal, but carbonaceous shale horizon at 133, 606, 605, 694, 709 and 1549½ft B.G.L.
20	Bambra (31 to 38)	Nil	Nil	Nil	Nil	453	Tert		Unknown	142 to 453	–	Brown coal, 3 layers 1 to 4ft thick and 41 to 51ft thick at 95 to 272ft – dip of B.C. West
21	Bambra (47)	Nil	Nil	Nil	Nil	542	Tert		Unknown	542	–	Brown coal 2ft at 468ft
22	Bambra (17)	Nil	Nil	Nil	Nil	148	Tert		Unknown	148	–	Brown coal 18ft at 113ft
23	Bambra (2)	Nil	Nil	Nil	Nil	320	Tert		Unknown	320	–	Brown coal 2 and 1ft at 63 and 220 ft resp
24	Bambra (3)	Nil	Nil	Nil	Nil	223	Tert		Unknown	223	–	No coal. Ironstone 1ft at 138ft B.G.L.
25	Yan Yan Gurt (29)	Nil	Nil	Nil	Nil	357	Tert		Unknown	357	–	Brown coal 24 and 1ft at 62 and 188ft resp
26	Yan Yan Gurt (32)	Nil	Nil	Nil	Nil	135	Tert		Unknown	135	–	Brown coal 3 layers 3, 1 & 2ft at 85, 89 and 96ft resp
27	Yan Yan Gurt (28)	Nil	Nil	Nil	Nil	309	Tert		Unknown	309	–	Brown coal 11ft at 281ft
28	Yan Yan Gurt (159)	Nil	Nil	Nil	Nil	24	Tert	46	Otways Group (Cret?)	100	–	No brown coal
29	Yan Yan Gurt (1 to 27)	Nil	Nil	Nil	Nil	357	Tert		Unknown	Deepest 357	–	Local area of brown coal outlined by drill holes. 2 layers 24 and 1ft at 62 and 188ft resp
COBDEN												
	Tandarook No 1	136	136	Nil	Nil	1731	Tert	1867	Otways Group	2029	Fresh	
	Carpendeit No 1	Nil	Nil	Nil	Nil	1148	Tert	1148	Otways Group	1853	–	
	Cooriejong No 1	Nil	Nil	Nil	Nil	1644	Tert	1644	Otways Group	2036	–	
	Elingamite No 1	63	68	Nil	Nil	2135	Tert	2203	Otways Group	2414	Fresh	Position unknown

DETAILED AEROMAGNETIC SURVEY,
WESTERN VICTORIA,
1968

LOCALITY MAP



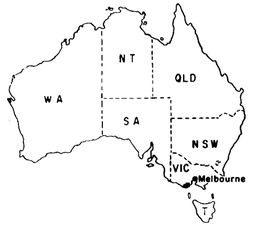
BASED ON J54/BO-1, J54/BI-43

SCALE

MILES 10 0 10 20 30 40 MILES

KILOMETRES 10 0 10 20 30 40 50 60 KILOMETRES

LOCALITY DIAGRAM

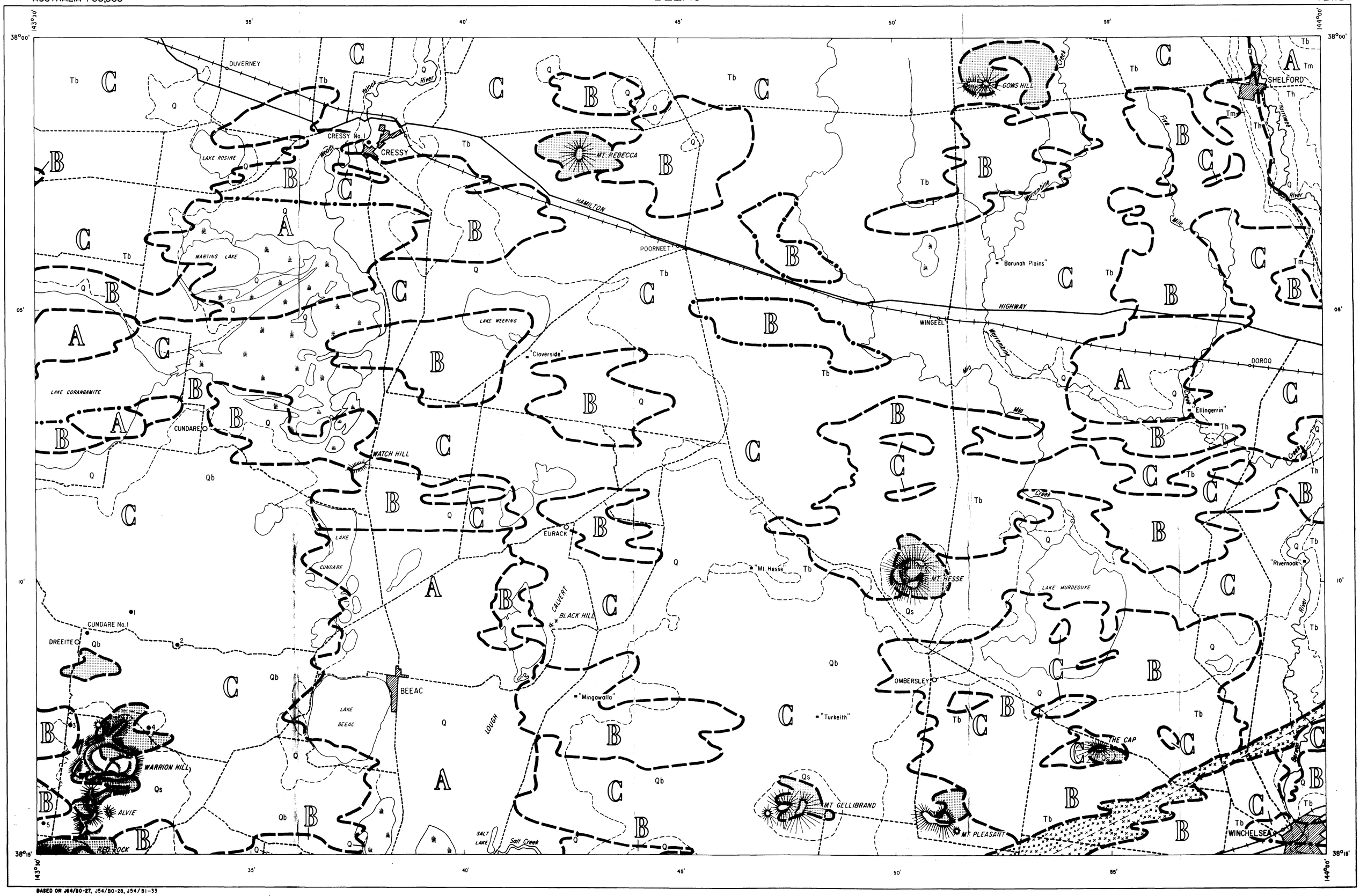


LEGEND

- Highway
- Railway
- Drill hole, named for reference
- Built-up area
- Town
- River or creek
- Lake or reservoir
- Mountain or hill
- Anticlinal thrust belt
- Boundary of survey area

J54/BI-42

To Accompany Record No. 1968/147



BASED ON J64/BO-27, J54/BO-28, J54/BI-33

GEOLOGICAL LEGEND

SEDIMENTARY ROCKS

QUATERNARY			Q	
TERTIARY	HEYTESBURY GROUP	MOORARBOOL VIADUCT FORMATION	Tm	Th

IGNEOUS ROCKS

QUATERNARY	NEWER VOLCANICS	LATER	PYROCLASTIC DEPOSITS	Qs	Basaltic tuff (or scoria), lapillistone, ash, cinders, scoriaceous basalt.
			LAVA FLOWS	Qb	Basalt, olivine basalt, (stony rises, valley flows).
TERTIARY		EARLIER		Tb	Basalt, olivine basalt.

Geological boundary, position accurate

Position of single drill hole numbered for reference ●5

GEOPHYSICAL INTERPRETATION AND GEOLOGY

MILES 1 0 1 2 3 4 5 6 MILES

KILOMETRES 1 0 1 2 3 4 5 6 7 8 9 KILOMETRES

NOTES

GEOLOGY AFTER 1:250,000 SCALE GEOLOGICAL SHEET, COLAC, NO. SJ54-12, PROVISIONAL EDITION, 1966, MINES DEPARTMENT, VICTORIA.

INDEX TO ADJOINING SHEETS

LISMORE	ROKEWOOD	MEREDITH
CORANGAMITE	BEEAC	GEELONG
COBDEN	COLAC	ANGLESEA

GEOPHYSICAL LEGEND

Zone boundary, definite

Zone boundary, tentative

A — *Magnetic zone, free from superficial basalt*

B — *Magnetic zone, probably covered by thin and/or weathered basalt*

C — *Magnetic zone, probable areas of thick fresh basalt*

Probable volcanic neck or cone

Zone of power line interference

TOPOGRAPHICAL LEGEND

Highway

Road or track

Railway and station

Powerline

River or creek

Dam

Lake

Swamp

Mountain or hill

Built up area

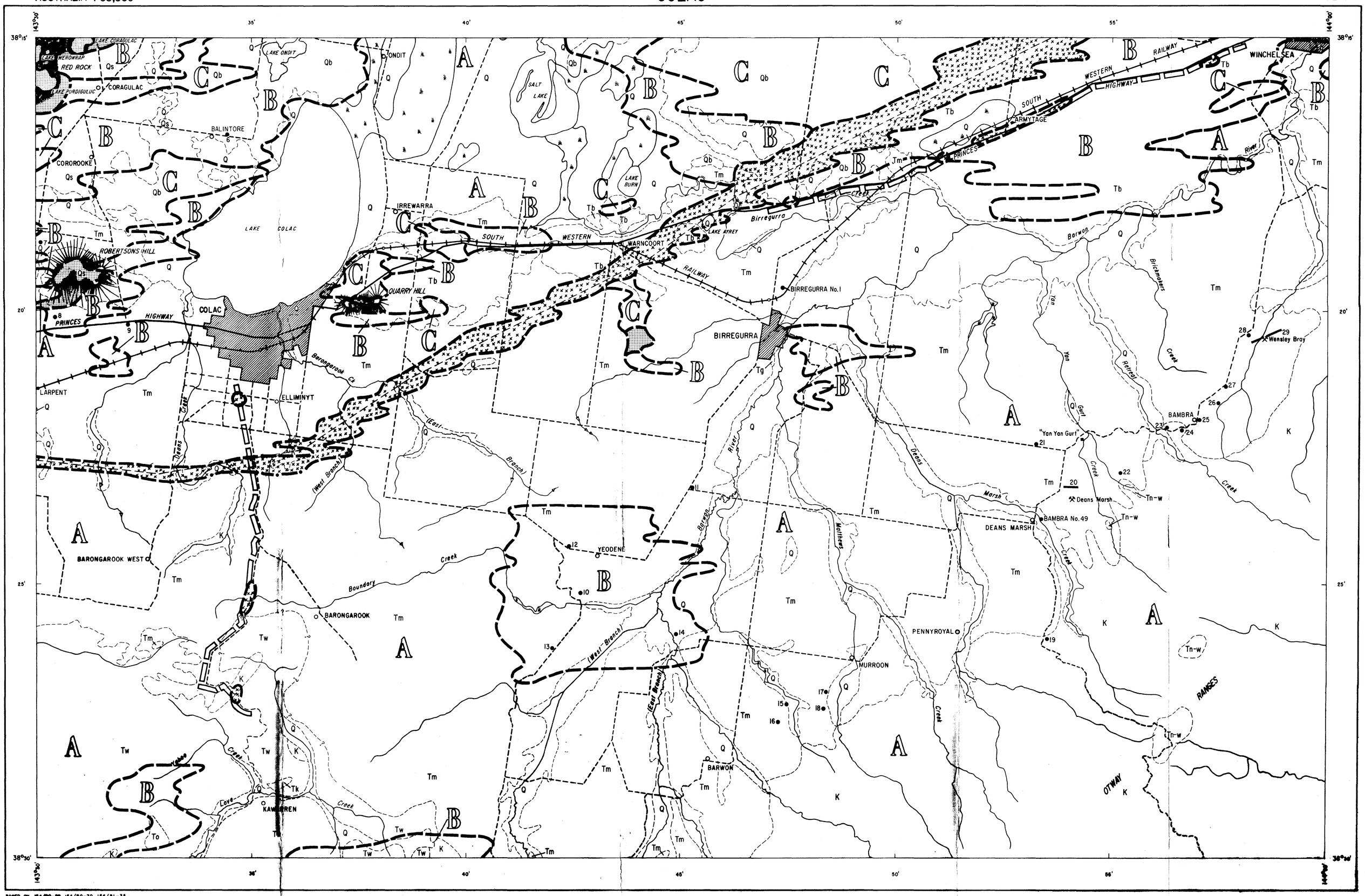
Named place

Homestead

To Accompany Record No. 1968/147

J54/BI-34

COLAC



BASED ON J54/B0-29, J54/B0-30, J54/B1-35

GEOLOGICAL LEGEND

SEDIMENTARY ROCKS

QUATERNARY				Q
TERTIARY	HEYTESBURY GROUP	MOORARBOOL VIADUCT FORMATION	Tm	Th
		GELLIBRAND MARL	Tg	
		KAWARREN GROUP	Tk	
	NIRRANDA GROUP EQUIVALENTS		Tn	
	WANGERRIP GROUP		Tw	
CRETACEOUS	KORUMBURRA GROUP (=OTWAY GROUP)		K	

IGNEOUS ROCKS

QUATERNARY	NEWER VOLCANICS	LATER	PYROCLASTIC DEPOSITS	Qs — Basaltic tuff (or scoria), lapillistone, ash, cinders, scoriaceous basalt.
			LAVA FLOWS	Qb — Basalt, olivine basalt, (stony rises, valley flows).
TERTIARY		EARLIER		Tb — Basalt, olivine basalt.
	OLDER VOLCANICS			To — Basalt.

Geological boundary, position accurate
Geological boundary, position inferred

Position of single drill hole numbered for reference ●7
Position of group of drill holes numbered for reference —20

GEOPHYSICAL INTERPRETATION AND GEOLOGY

MILES 1 0 1 2 3 4 5 6 MILES

KILOMETRES 1 0 1 2 3 4 5 6 7 8 9 KILOMETRES

NOTES

GEOLOGY AFTER 1:250,000 SCALE GEOLOGICAL SHEET, COLAC, NO. SJ54-12, PROVISIONAL EDITION, 1966, MINES DEPARTMENT, VICTORIA.

INDEX TO ADJOINING SHEETS

CORANGAMITE	BEEAC	GEELONG
COBDEN	COLAC	ANGLESEA
PRINCETOWN	BEECH FOREST	

GEOPHYSICAL LEGEND

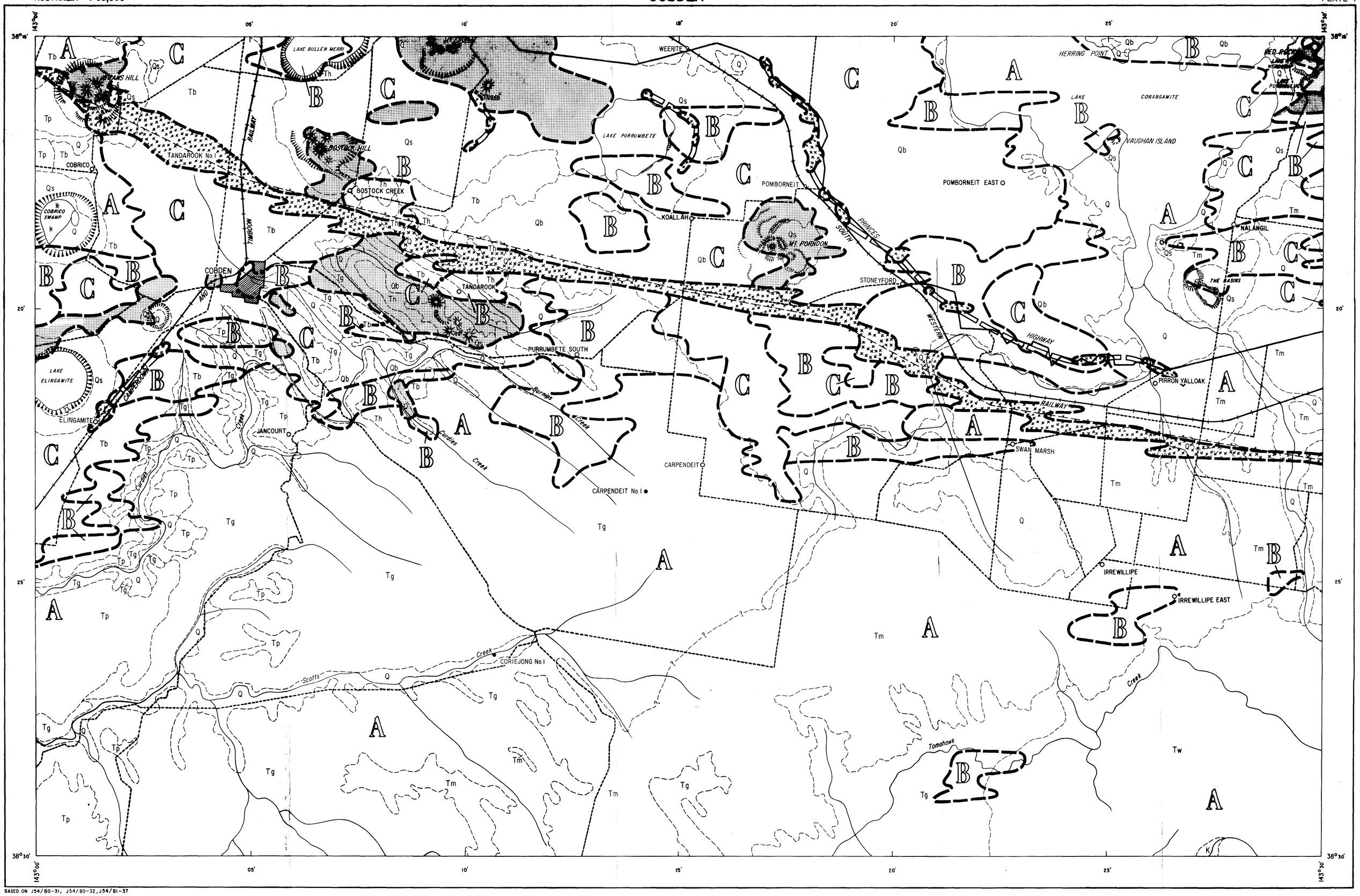
- Zone boundary, definite
- Zone boundary, indefinite
- A — Magnetic zone, free from superficial basalt
- B — Magnetic zone; probably covered by thin sand/or weathered basalt
- C — Magnetic zone; probable orders of thick fresh basalt
- Probable volcanic neck or cone
- Zone of power line interference

TOPOGRAPHICAL LEGEND

- Highway
- Road or track
- Railway and station
- Powerline
- River or creek
- Dam
- Lake
- Swamp
- Mountain or hill
- Built up area
- Named place
- Homestead
- Open cut mine

To accompany Record No. 1968/147

J54/B1-36



BASED ON J54/BO-31, J54/BO-32, J54/BI-37

GEOLOGICAL LEGEND

SEDIMENTARY ROCKS

QUATERNARY			Q	
TERTIARY	HEYTESBURY GROUP	MOORARBOOL VIADUCT FORMATION	Tm	Th
		PORT CAMPBELL LIMESTONE	Tp	
		GELLIBRAND MARL	Tg	
	WANGERRIP GROUP		Tw	
CRETACEOUS	KORUMBURRA GROUP (=OTWAY GROUP)		K	

IGNEOUS ROCKS

QUATERNARY	NEWER VOLCANICS	LATER	PYROCLASTIC DEPOSITS	Qs	Basaltic tuff or scoria lapillistone, ash, cinders, scoriaceous basalt.
			LAVA FLOWS	Qb	Basalt, olivine basalt (stony rises, valley flows).
TERTIARY		EARLIER		Tb	Basalt, olivine basalt.

Geological boundary, position accurate
Geological boundary, position inferred

Position of single drill hole

GEOPHYSICAL INTERPRETATION AND GEOLOGY

MILES 1 0 1 2 3 4 5 6 MILES

KILOMETRES 1 0 1 2 3 4 5 6 7 8 9 KILOMETRES

NOTES

GEOLOGY AND TOPOGRAPHY AFTER 1:250,000 SCALE GEOLOGICAL SHEET, COLAC, No. SJ 54-12 PROVISIONAL EDITION, 1966, MINES DEPARTMENT, VICTORIA

INDEX TO ADJOINING SHEETS

MORTLAKE	CORANGAMITE	BEEAC
PANMURE	COBDEN	COLAC
PORT CAMPBELL	PRINCETOWN	BEECH FOREST

GEOPHYSICAL LEGEND

Zone boundary, definite
Zone boundary, tentative
A — *Magnetic zone, free from superficial basalt*
B — *Magnetic zone; probably covered by thin and/or weathered basalt*
C — *Magnetic zone; probable areas of thick basalt*
Probable volcanic neck or cone
Zone of power line interference

TOPOGRAPHICAL LEGEND

Highway
Road or track
Railway and station
Powerline
River or creek
Dam
Lake
Swamp
Mountain or hill
Built up area
Named place
Homestead

To Accompany Record No. 1968/147

J54/BI-38