# REPORT ON

# AIRBORNE MAGNETOMETER SURVEY

# OF

# BASS STRAIT AND ENCOUNTER BAY AREAS, SOUTH-EASTERN AUSTRALIA

## APPENDIX I

Notes on geological interpretation of magnetic features - Bass Strait and Encounter Bay.

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Haematite Explorations Pty. Ltd.

October, 1962.

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# COMMENTS ON, AND CONCLUSIONS FROM THE CORRELATION OF MAGNETIC DATA WITH KNOWN GEOLOGY.

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ABSTRACT:

The geological study of the underwater shelf areas of south-eastern Australia can only be based on the projection of geological boundaries, structures and trends from Victoria, Tasmania and South Australia; and on geophysical evidence.

No previous geophysical work had been done in the area over which our subsidised aeromagnetic survey was carried out, but in the assessment of the results, information has been drawn from prior geophysical surveys in the surrounding areas, viz.

(i) aeromagnetic surveys over Kangaroo Island, the Mt. Lofty Ranges and the Murray Basin in South Australia; the Gippsland Basin and the adjacent off-shore area in Victoria; and over north-west Tasmania;

(ii) gravity surveys over the Gambier Sunklands, South Australia; and over the Otway Basin and Port Phillip Bay, Victoria;

(iii) seismic surveys over the Gambier Sunklands, South Australia; and over the Otway and Gippsland Basins, Victoria.

The recent aeromagnetic survey has outlined areas of basinal deposition which may have been favourable for the accumulation of petroleum. Sedimentation in these basins

was probably confined to late Jurassic, Cretaceous and Tertiary times, although there is evidence to indicate that Middle Devonian-Permain sediments may underlie the Bass Strait and Gippsland areas, but are not confined to the basins.

The geological review of the magnetic results deals with the geological history and the eventual breakdown of this area of the Tasman geosyncline to form the basins of deposition referred to in the previous paragraph. It is thus the summation of -

(i) interpretation of the magnetic features, and,

(ii) theoretical aspects of the formation of Bass Strait and of other similar structures in the bordering States.

Notwithstanding the comments submitted, the magnetic results are expected to produce additional information when they are re-examined in conjunction with the results of the proposed seismic survey.

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## GEOLOGICAL REVIEW - AEROMAGNETIC RESULTS

Magnetic features may be related to:

| | | |
|---|---|---|
| Basement - | Precambrian - Cambrian | ... Strong features |
| | Ordovician - Silurian, Granite intrusives | ... Weak features |
| | Faulting - | ... Features depend on the rock types in juztaposition. |

Basic Rocks in Sedimentary Section

Tertiary basalt - Eocene or Pliocene

Dolerite - Jurassic (Tasmania)

The discussion of the relationship between geology and magnetics is referred to the more important basins of sedimentation which have been defined as a result of the magnetometer survey.

1. ENCOUNTER BAY AREA - OTWAY BASIN (GAMBIER SUNKLANDS):

This area is clearly divided into two parts. North of an east-west line, just south of latitude 37°S, shallow basement features predominate whereas to the south of it the depth of sedimentation increases rapidly within the Gambier Sunklands of the Otway Basin.

(a) Basement Complex:

The Encounter Bay area from Kangaroo Island to the Coorong forms part of the Mt. Lofty - Kangaroo Island arc of Pre-Cambrian metamorphics, flanked to the east and south by geosynclinal deposits of the Kanmantoo Group (Cambrian). Basement trends are east-west beneath the continental shelf south of Kangaroo Island. Further eastward these become complex and variable until north-south trends are predominant adjacent to the small graben (between latitudes 139°10' and 139°40') and also on the Padthaway Horst where they have been defined by aeromagnetic survey of the Murray

Basin.

The graben, bounded by north-south down-to-basin faulting, contains an estimated 3,000 - 4,000 feet thickness of sediments. The faulting on the western side of the graben is probably an extension of the eastern boundary faults of the Mt. Lofty Ranges.

The sediments within the graben may be the result of deposition from the Murray River which flowed westerly until reaching the early Tertiary fault escarpments of the Mt. Lofty Ranges, then diverted to the south along the strike direction of the fault blocks. Deposition in the graben may have been confined to post-Cretaceous times.

Another small graben of moderate sediment depth occurs on the margin of the continental shelf (south-west part of Sheet 5) but sedimentation in this area is more probably related to the main Otway Basin than to discharge from the Murray River.

Areas of shallow magnetic relief within the basement complex may be correlated with post-Cambrian granitic intrusions such as outcrop on Kangaroo Island, near Victor Harbour, and Kingston, and at isolated areas on the Padthaway Horst.

(b) Gambier Sunklands of the Otway Basin:

The faulted margin of the sunklands extends easterly onshore to the zone of the Lucindale Fault, as outlined by aeromagnetic data obtained by the S.A. Mines Department. The inference drawn from comments by M. Reford concerning the magnetics in the sunklands area (P. 38, para. 2: p.41, para. 3) is that a very deep sedimentary section exists throughout, with the exception of the pronounced basement high near Beachport. Estimations of depths-to-basement from the magnetic profiles are based on insufficient features to properly determine depth variations. The basin structure as outlined by the depth-to-basement contours serves only to illustrate that the section is thick and that the basement slopes steeply to the south.

Near Beachport, two major features, both related to basic rocks within the basement, have been studied. One feature (8 - 4* : 9 - 2) extends westerly from the coastline at Beachport with increasing depth to basement in this direction. The second (9 - 5) was analysed by M. Reford (p.40) as a typical dyke model of basic material dipping south-west at 60°, 22,000 feet in width and with its upper part 16,000 feet below sea level. A related minor feature (within 9 - 5) is thought to be related to basic intrusives at 4,000 feet below sea level. These two features indicate a steep slope of the basement surface to the south. The common apex of these major features is the basement high as outlined by the gravity and magnetic anomalies centred approximately five miles north of Beachport.

M. Reford draws attention (p.40, para. 1) to the similarity between this coastal magnetic feature (9 - 5) and a belt of magnetic relief trending north-westerly from Mt. Gambier to Beachport, as recorded by the S.A. Mines Department Survey. The latter belt follows the zone of volcanicity (Mt. Gambier - Mt. Burr) and the coastal feature may have a similar origin but with no surface expression of the volcanics. An area is shown on Composite "A" in the vicinity of Beachport which may be underlain by volcanics within the sedimentary section. Structural control for these zones of volcanicity may be provided by faulting within the sunklands.

A broad magnetic low, related to the modern continental margin, trends south-easterly in the south-east part of Sheet 8

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* (8-4) refers to area number 4 on sheet 8, and as marked on the composite maps.

and deviates to a more easterly direction (Sheet 9) away from the modern margin. It crosses the coastline north of Douglas Point and is probably related to the margin of the continent in some earlier geological period, possibly Cretaceous-Eocene.

2. OTWAY BASIN:

Geological evidence in Victoria shows the Otway and Gippsland Basins presently separated by the Mornington Peninsula which has a south-west trend. The continuation of this trend, i.e. the Phillip Island - King Island basement high, forms the ridge between the Otway Basin and the Bass Basin as defined by the airborne magnetometer "depth to basement" estimates.

The ridge is a borad feature, up to 35 miles wide, and its crest has a gradual slope to the south-east. To the northewest it appears to be faulted down-to-basin by a continuation of the Selwyn Fault. Smaller north-south faults are postualted on either side of the basement ridge, those on the north-west side forming part of a mosaic fault block pattern with areas of positive basement relief and also of deeper sedimentation. The largest area of moderate sediment depth is easterly from Lorne and probably extends into Port Phillip Bay. The Younger Basalts (Pliocene) mask the basement magnetic relief along the northern side of the basin but the Anglesea Well and the results of the B.M.R. gravity survey of Port Phillip Bay suggest deep basement in that direction.

North-west of a line trending south-west along and beyond the Otway coast, the magnetics indicate deep basement with shallow basaltic activity in the offshore area. Areas of small "seaknolls" with up to 210 ft. of relief above the ocean floor at 39°S, 143°25'E and 39°7'S, 143°15'-20'E. may be related to these basalts.

The prominent basement trends south-east of Cape Otway may be correlated with the structural trends of King Island and hence may represent basement at a shallow depth. The rapid rise of the basement floor east and south-east of Cape Otway may be related to a fault zone on which later, and reversed, movement elevated the Otway Ranges to their present relief during the Tertiary epeirogenic movements.

The magnetic survey along the western Victorian coast provided only sparse coverage and no conclusions may be drawn regarding the structure of the deeper parts of the Otway Basin. Shallow volcanics have been fortuitously outlined by the flight pattern.

The Phillip Island - King Island ridge is overlain by Older Basalt (Eocene) on Phillip Island and along the southern coast of Mornington Peninsula. The basalt appears to extend along the basement ridge for a distance of some 30 miles southerly from Cape Schank. The band of "steep magnetics" along the southern side of the ridge suggests a series of en echelon north-south faults rather than a single fault zone. Such en echelon faults are shown diagrammatically on Sheet 21, Composite "B".

3. BASS BASIN:

The major deep basinal structure within Bass Strait trends north-west to south-east across Sheets 22, 27 and 28 and conservative estimates indicate thicknesses of sediments up to 12,000 ft.

(a) Margin of Basin:

A basinal area of shallow depth occurs south of Wonthaggi and is bounded on the south-east side by a trend which forms the extension of one of the epeirogenic boundary faults of the South Gippsland Highlands. On either side of this basin, which deepens to the south-west, large magnetic anomalies occur. Those which are south of Cape Liptrap may reflect an offshore extension of outcropping (?) Cambrian greenstone and diabase and, if so, these offshore rocks are probably faulted, along their western boundary, against Devonian limestones. The large anomaly south of Phillip Island (south-west Sheet 16) may also be related to (?) Cambrian rocks as the normal basement in the Wonthaggi area comprises weakly magnetic Silurian metamorphic rocks.

There is evidence that the Bassian Rise, a submarine ridge connecting Flinders Island and Wilson's Promontory, is composed of granite intrusives in Silurian metamorphics. Resistent granite forms the many islands along the Rise. "Basement" is virtually non-magnetic with small anomalies up to five gammas but similar profiles were recorded over the granitic rocks of Flinders Island. There is a sharp change in basement rock types in the area west of Wilson's Promontory towards Cape Liptrap.

Geological evidence from Tasmania, Flinders Island and Wilson's Promontory suggests that the whole of Bass Strait east of longitude 146°30'E is probably underlain by a "basement" of weakly magnetic Silurian rocks with granite intrusives. It seems likely that many anomalous features, trending north-west to south-east and with magnitudes up to 250 gammas, may be related to the dolerite sills as noted on the north-east part of Tasmania (Ringarooma Bay). Some of these areas are shown on the map. The dolerites intrude Pre-Cambrian, Lower and Middle Palaeozoic rocks as dykes, and spread out as sills within the Permian and Triassic sediments of Tasmania. The magnetics may therefore relate to north-west trending dykes within the sediments of the Mathinna Group (Silurian) or to sills in Permian strata, preserved on down-faulted blocks in a similar manner to the dolerites of the Launceston Basin.

Basement magnetics b ecome more pronounced along the south-western side of the Bass Basin, east of the southern tip of King Island, and the magnetic trends conform to the north-south trends in the Pre-Cambrian and Lower Palaeozoic rocks of King Island and of the north-west part of Tasmania. Tertiary volcanics extend along the north-west coast of Tasmania from Devonport to Cape Grim. Only isolated flight lines crossed this area of shallow basement and the submarine boundaries of the basalts may be indicated in a broad sense by the value of the magnetics, as shown diagrammatically on Composite "C".

"Depth to basement" estimates do not indicate any connection between the Bass Basin and the Launceston graben which, although they have similar areal extent and strike direction, differ greatly in the depth of sedimentation.

A small graben, parallel to the Otway structures, is shown between King Island and the islands off north-west Tasmania, but is separated from the main Bass Basin by shallow basement.

(b) Deep Sedimentary Basin:

There are two major magnetic features of the Bass Basin which occur in its deepest part. They are separated by a north-south trending magnetic low which may reflect the effects of a north-south fault along longitude 145°30'.

The major features, shown on Sheets 22 and 28, both appear to be related to basic intrusion and analyses indicate that these bodies have similar strikes, dips and thicknesses.

It is considered that the magnitudes of the magnetic anomalies indicate intrusive basic material rather than variations in the basement rock types as they are known in Victoria and Tasmania. Massive dolerite intrusives may be the source of the magnetic anomalies in dyke form within the

Palaeozoic basement, or as a sill in Permian or Triassic strata. If a sill, the depth to the basement may be considerably greater than that shown. The estimate of 15,800 feet to the third interface on anoamly 22 - 1 and the north-east dip of that feature possibly indicate the attitude of the basement. (See Fig. 1 and 2). However, the manner of intrusion of the dolerite, which is considered to have taken place in Mid-Jurassic time is not of significance.

4. GIPPSLAND BASIN:

The B.M.R. aeromagnetic survey (1956) of the offshore Gippsland area covered the major part of this Basin and our work was planned to extend the coverage over the southern part adjacent to the Bassian Rise.

The two surveys matched well, as exemplified by the magnetic record between Wilson's Promontory and Cape Liptrap and by the characteristic change in strike of the belt of magnetic maxima at 39°S, 147°30'E. Interpretation of the B.M.R. results was carried out by J.H. Quilty (Record 1962/53) and this interpretation has been accepted. The following comments therefore deal principally with the southern part of the basin.

North-easterly basement trends as recorded from the B.M.R. survey are evident beneath the southern part of the Gippsland Basin, and no variation in basement trends are evident under the whole of the Gippsland Basin extending eastward from Western Port Bay to east of Lakes Entrance.

The belt of magnetic maxima shown by both surveys (above) was analysed and indicated a typical dyke model 9,000 feet wide at a depth of 5,000 feet. Rising above the general basement level, it is composed of basic material but cannot be related to any surface feature.

Evidence of the taphrogenic breakdown of the Gippsland Basin is provided by the marginal down-to-basin faulting , in particular the major fault extending eastward from Lake Wellington along the northern side of the basin. (Refer B.M.R. Record 1962/53). A complementary marginal fault trending east-west (south-east of Sheet 18) is postulated to terminate basement magnetic trends on the southern flank of the basin area and is supported by depth-to-basement estimates and the configuration of the basin. Surface expression of this fault is shown by the sharp change of alignment of the continental margin at 38°45'S, 148°20'E.

## GEOLOGICAL COMMENTS ON SOUTH-EASTERN AUSTRALIA:

The following notes comprise a summary of geologic history of the area under review, and a discussion of a possible method of formation of Bass Strait with reference to the main geological features of south-eastern Australia.

### Basement Framework:

Deposition in the Tasman geosyncline built up in an easterly direction commencing with the Cambrian Kanmantoo Group along the eastern flank of the Archaeozoic-Proterozoic core of the Mt. Lofty Ranges. It ended with the major Bowning and Tabberaberan orogenic movements of the Silurian-Devonian during which the granitic intrusions in north-east Tasmania and the Bassian Rise were emplaced. The regional "grain" of the early and mid-Palaeozoic rocks is meridional with local variations from north-west to north-east. Some faunal relationship has been established between the Cambrian rocks of Victoria and Tasmania but there are no rocks in Victoria which are equivalent to the (?) Pre-Cambrian rocks of Tasmania. The Tyennan Geanticline of Tasmania must therefore constitute a separate basement complex to the south of the Tasman geosyncline. However, after the early Palaeozoic, the geological environment in Tasmania and Victoria became similar as it is believed that the Mathinna Group of Tasmania can be correlated with the Silurian sediments of Victoria, and likewise the granitic intrusions within these sediments are probably of the same or similar age as each other.

Terrestrial sediments were deposited in late Devonian-Carboniferous times in broad synclinal depressions formed during the previous orogenic movements. These sediments occur in Victoria in the Mt. Wellington-Mansfield belt and at the Grampians.

There were three major thrust belts associated with the late Palaeozoic orogeny in Victoria (D.E. Thomas, 1958). The most westerly of these, the Stavely Belt along the eastern side of the Grampians, may have influenced the location of the west coast of Tasmania and King Island (see page 13).

## Late Palaeozoic - Mesozoic Sedimentation:

Deposition in Tasmania in Permian - Middle Triassic times covered most of the island and extended into Bass Strait. Sediments, often tuffaceous, were alternatively marine and fresh water. Dolerite intrusions took place, probably during Jurassic time, as dykes along faults between blocks of sediments, and as sills in the Permian and Triassic strata.

## Formation of Bass Strait:

S.W. Carey (ANZAAS Sydney, 1962) suggested that the formation of Bass Strait resulted from east-west transcurrent faulting in Victoria, through Gippsland and south of the Dividing Range. The movement was postulated as south-block-west, the westerly shift producing a series of en echelon faults which "moved" Tasmania to its present position.

Evidence from the magnetic survey supports the theory that the taphrogenic breakdown of Bass Strait was controlled by crustal movements but it is considered that such movements may have been derived from rotational stress rather than from a major transcurrent fault system. Such rotational stress is evidenced by:

(a) The en echelon fault pattern along the south-eastern side of the King Island - Phillip Island ridge,

(b) The offset of the main magnetic feature in the basinal part of Bass Strait (assumed to be derived from dolerite) which may be due to rotational stress producing movement along a north-south transcurrent fault.

The Stavely thrust belt (p. 12) may have originally continued to the south as far as Tasmania, and have been subsequently displaced by the rotational movement and associated faulting suggested above. The fault zone may thus now define the continental margin along the western coasts of Tasmania and King Island.

It is postulated that this breakdown post-dated the dolerite intrusion in Tasmania and the resultant movement of Tasmania relative to the mainland produced the major rift valley in southern Victoria which received sedimentation during Upper Jurassic to Lower Cretaceous times.

Late Mesozoic - Tertiary:

At the conclusion of the deposition of great thicknesses of arkosic sediments in the rift valley of Victoria, normal down-to-basin faulting took place in western Victoria and South Australia so allowing marine transgression and deposition of the Middle Cretaceous Belfast Group. Typical features in the Otway Basin were down-to-basin fault blocks with horst and graben topography superimposed across the basin strike direction. Similar features are not apparent on the landward expression of the Gippsland Basin.

The Bass Basin appears to be separated from both the Otway and Gippsland Basins and the control of deposition and facies variation within the Bass Basin cannot be interpreted at this stage. From evidence around its margins it is expected that a great part of the section will be Tertiary sediments.

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## BIBLIOGRAPHY

D. E. Thomas - 1958. The Geological Structure of Victoria. Journal Royal Society of N.S.W. Vol92, Pt.IV, P.182.

S. W. Carey - 1962. ANZAAS Sydney - Symposium "Tectonics of Australia".

S. Gunson, L. W. Williams and J. C. Dooley - Preliminary Report on Gravity Survey of Pt. Phillip Bay. B.M.R. Record 1959/34.

J. H. Quilty - Gippsland Basin Airborne Magnetic Surveys, Vic. B.M.R. Record 1962/53.

S.A. Mines Department - Results of airborne magnetic surveys in South Australia.

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# SKETCH SECTION
# BASS BASIN
## LONG. 146° 00'

SCALES: Horizontal : 1 Inch = 16 Miles.
Vertical : 1 Inch = 4000 Feet

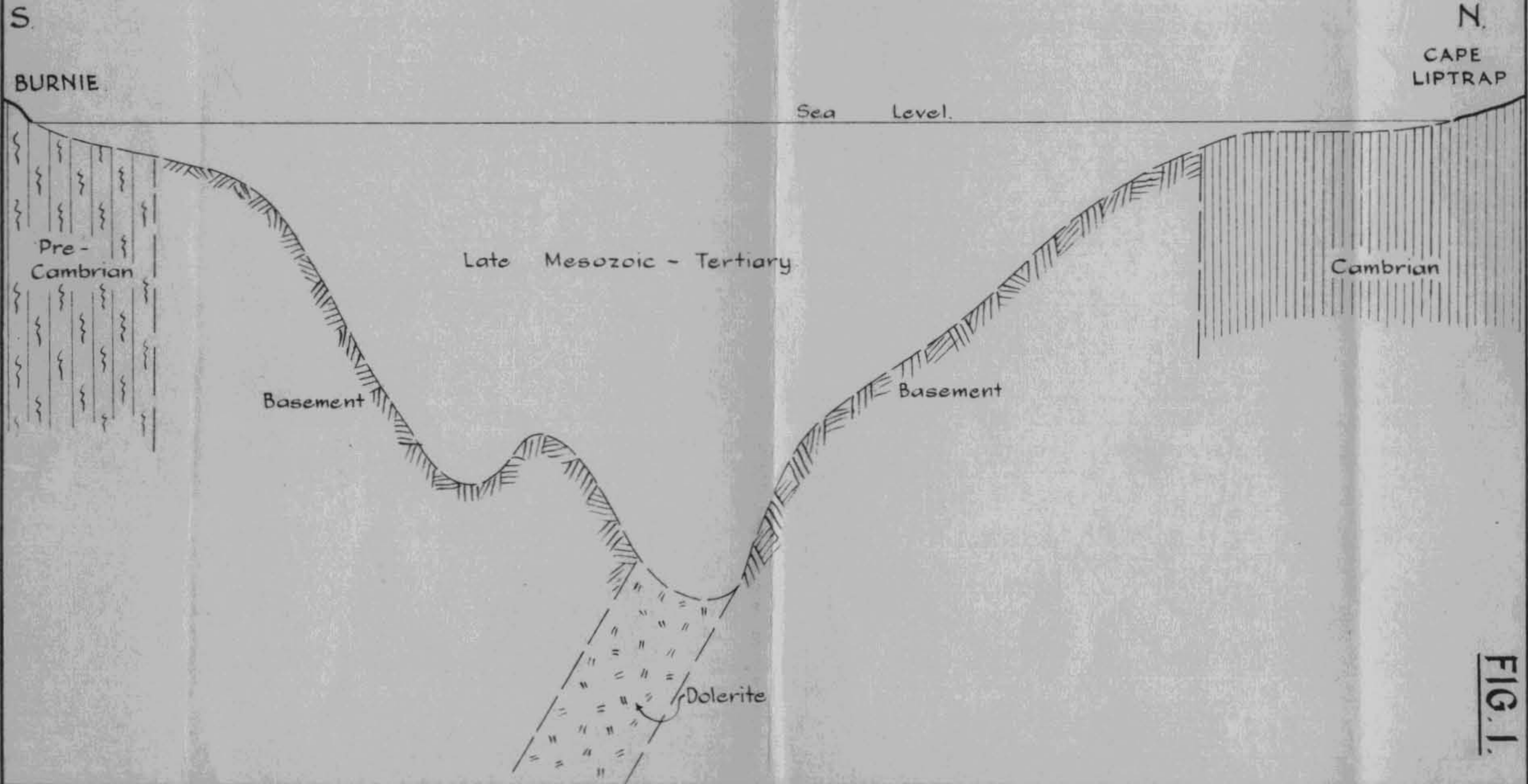


FIG. 1.

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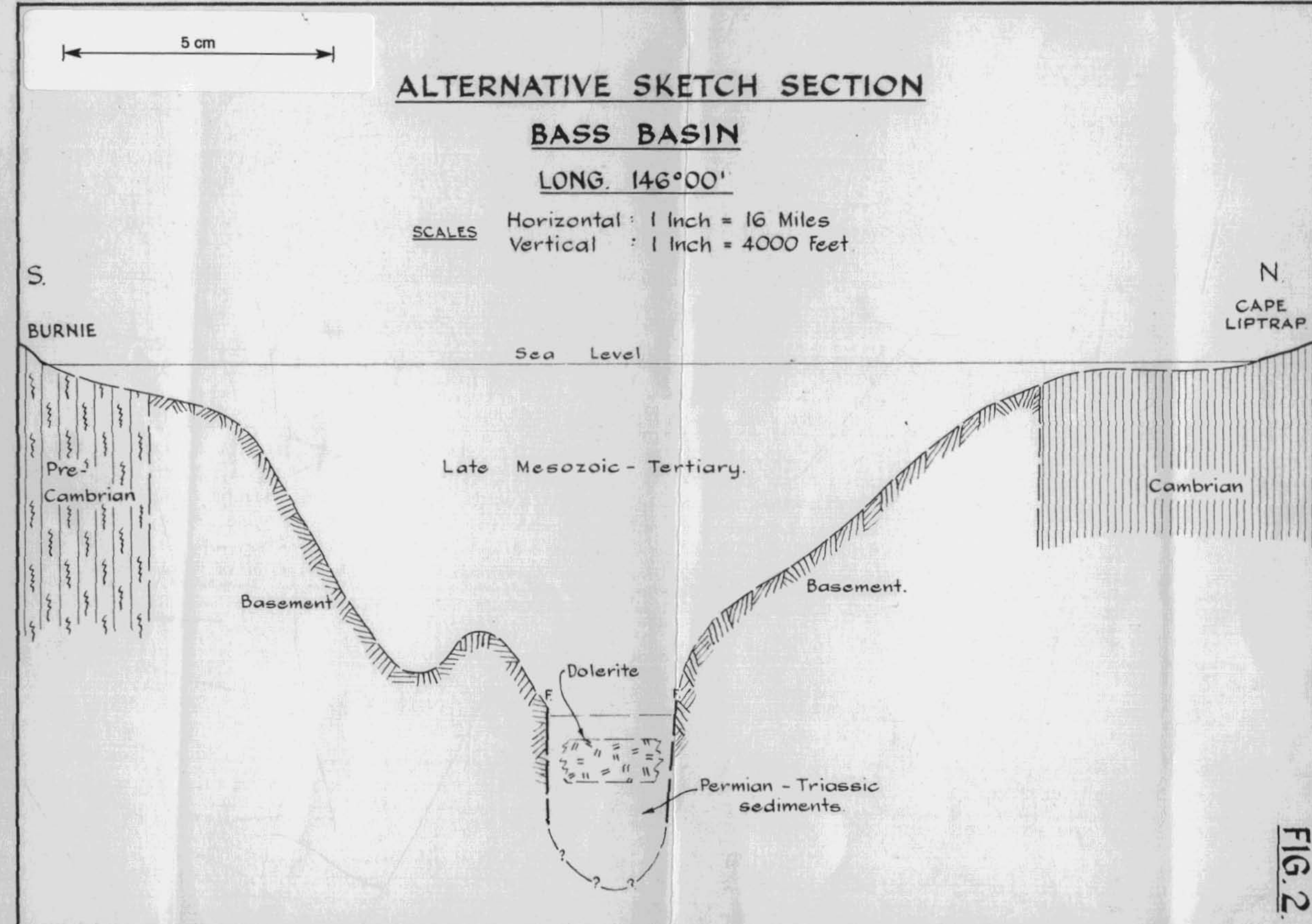


FIG. 2.