

MICROFILMED

FIRST ANNUAL REPORT
YEAR ENDED AUGUST 31, 1987

CONGA OIL PTY LTD
PROJECT D'ENTRECASTEAUX

LICENCES:

29/84; 6/86; 7/86; 52/86; 53/86
8/87; 9/87; 10/87; 11/87; 12/87; 13/87; 14/87; 46/87

by

Dr. D.E. Leaman

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AUG 1987

Report prepared for Conga Oil Pty Ltd
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4. Review of the hydrocarbon prospectivity of EL 29/84 onshore Tasmania by J. N. Mulready.
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INTRODUCTION

This first annual report for Project D'Entrecasteaux by Conga Oil Pty Ltd in Southern Tasmania represents consolidated reporting for all adjacent licences in the region. A previous annual report was provided for EL 29/84 only.

This report presents a summary of completed exploration, exploration philosophy, licences, reasons for acquisition, expenditure and programmes proposed.

Conga Oil Pty Ltd was founded by Mr. M.R. Bendall in 1984 to explore for the oil seeps which had been reported on North Bruny Island in 1909 and 1929 (Appendix 4). A small licence area (29/84) was sought and was ultimately granted in June 1985. Until November 1986 all work was restricted to this area. Applications were made for increase of this area after it became apparent that the seepage had been re-discovered, was legitimate and some indication of the origin of the hydrocarbons (Appendix 2) and the nature of possible plays inferred (Appendices 3, 4).

As there have been several generations of licence applications, due to the realisation of the implications of data recovered in late 1986 and early 1987 (Appendices 2, 3), each with quite different reporting dates, a fixed notional date has been negotiated for reporting all licences. It will be noted that only 29/84 has applied for the 12 month period to August 31, 1987; all other licences were granted during the period and some are still pending.

This means that this report largely presents work on EL 29/84 but also includes the regional studies and appraisals which led to the expansion of licence areas. Consequently, material relevant to all licences, even those pending, is included in the report. It provides explanation of the philosophy which led to the applications and the foundation for all future work across the region.

Early in 1987 ownership of Conga Oil Pty Ltd was changed from a family company to a partnership with I. Herzog and M. Lasky of Melbourne. This has guaranteed the stability of the company, given it a solid financial base, and ensured a comprehensive exploration programme.

After it became evident late in 1986 that the reported Bruny Island seep was of true mineral oil various surveys and programmes were considered. The suggestion that hydrocarbons might be derived from Ordovician rocks (Appendix 1) and the indication from extant regional geophysical data of a major Palaeozoic section in the region (Appendix 3) led to the partners ordering a regional geophysical research programme. This consisted of an aeromagnetic survey and an infill gravity survey and was undertaken notwithstanding the risk of non renewal of the core licence (29/84), then delayed and under review, and the long delayed granting of 6/86 and 7/86 which had been sought on the early indications of work described in Appendix 1. It appears that the concept and the necessary programme was thought beyond reality or the ability of the company to support. The confirmation of the seep and its

chemistry rather changed the first part of this equation and the new partners the second part.

In any event the regional surveys were completed before the granting of any new licences in 1987, any processing of the new applications or the belated renewal of 29/84. This history is mentioned here to account for the absence of any complete presentation of this data in this report even though compilation maps are supplied as Figures 2 and 3. The work was not completed as part of any exploration other than in respect of EL 29/84, even though the works were proposed in the works programmes sketched in the applications, and the partners have now defined it as research. It has not been costed against the works programme commitments for any licence although a very small proportion has been charged to 29/84. Results relevant to this licence are included in Appendix 5 and Figures 4 to 6. The partners have not yet, however, approved release of the entire data base. This wholly regrettable situation derives from a lamentable lack of good will between the original Conga Oil and the Department of Mines but may yet be overcome. As conscripted agent (at behest of both Conga Oil and Minister for Mines) it seems to me that there is a lesson here for both explorers and administrative staff. Explorers with innovative or unconventional concepts should present them well; but questions of scientific feasibility are irrelevant provided financial commitments are met, as they were here. No government administration should ever seek to tell an explorer how to risk his capital or frustrate him in any legal application to do so. History is full of examples where a small budget backed with ideas is worth more than a bank with old notions. All explorers deserve a chance. Any dictation on how to explore must always be unacceptable, suggestions without threat of licence loss welcomed. A licence should never be withheld on the basis of personality or concept, especially where there is no queue of alternate applicants. Granting of licences was accelerated after discussions between the new partners and the Minister in April 1987 but the geophysical surveys had already been completed.

Interpretation of the acquired data base is proceeding and full details will be included in the next annual report. The gravity and magnetic compilations upon which that interpretation is being largely based have been included (Figures 2 and 3).

The report is therefore complete in all respects with regard to licence conditions for areas actually granted prior to work done and, in large measure, the spirit of those conditions for work done on areas not granted, pending or sought at the time the work was done.

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LICENCES

Held in the name of Conga Oil Pty Ltd, Southern Tasmania.

All are held for oil and coal.

PROJECT D'ENTRECASTEAUX

	applied	granted
29/84 Lagoon Hill, North Bruny	190584	100685
6/86 Catamaran	110386	250387
7/86 Southport	120386	250387
52/86 Bruny Island	231286	290487
53/86 Bruny Island	231286	290487
8/87 South Bruny	120287	#
9/87 South Bruny	120287	180687
10/87 South Arm	120287	*
11/87 Grove	120287	*
12/87 Judbury	120287	#
13/87 Waterloo	120287	180687
14/87 D'Entrecasteaux River	120287	180687
46/87 Boyer	30687	##

Consolidated reporting date: August 31

* Pending. At Minister's discretion after Warden's Court

Pending processing prior to advertisement.

Pending grant after clearance at Warden's Court.

All licences are held under the Mining Act as mineral exploration tenements. This is an awkward and unrealistic situation for any onshore petroleum explorer since the area limits and requirements for such exploration are very different from those for mineral exploration. Tasmania is out of step with other Australian states in this respect and legislative provision should be made for such exploration whether or not the present venture is successful.

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EXPLORATION HISTORY AND OBJECTIVES

OUTLINE:

Hydrocarbon seepages have been reported at several sites in Southern Tasmania over the years. Only that at North Bruny was taken seriously and an attempt was made to drill about 50 years ago (see also Appendix 4). The occurrences have not been verified since and were largely discounted. I personally sought out the reported Cygnet occurrence more than twenty years ago but applied the rose glasses of the day when describing the site (Leaman and Naqvi, 1967). It has always been easier to describe a surface scum as an iron rather than an oil scum especially when the occurrence is marginal and uncertain and unambiguous technology is not available to resolve the issue.

EL 29/84, however, was taken out on the basis that there was some fact in the North Bruny occurrence. The first object was to relocate the site and make some judgment upon it. At this time it was believed that the hydrocarbons, if present, were probably derived from Permian oil shales even though no exposure of these rocks is known south east of Maydena. At about the same time conodont colour studies from the Ordovician Gordon Limestone were suggesting that in this part of Tasmania these units are within the oil window (see Appendix 1). Since most of this work was inevitably concentrated near the available exposures additional licences (6/86, 7/86) were sought to cover the possibility that the limestone was a viable source rock.

Exploration of 29/84, meanwhile, had been predicated on the dual assumptions that oil could be either Permian or Ordovician in origin. If Permian then relatively shallow exploration could be envisaged and an appraisal of dolerite forms would be crucial. No significant migration was likely. Should the latter have been the case then the exploration had to consider any shallow structural implications as well as gross, deeper and wholly concealed factors. The area held would be too small in this case since an array of migration paths and potential trap - source relationships could be conceived.

The suggestion, on the basis of initial sampling results (Appendix 2), that there was a true mineral oil seepage on North Bruny and that the hydrocarbons were derived from an old limestone source set the project alight. These conclusions stand notwithstanding the less than ideal nature of the original sampling and the small concentration of indicator compounds. The results suggested that exploration may not have to consider Permian source rocks which certainly do not appear to exist at Cygnet, Woodbridge or South Bruny where correlates are exposed and that the programme would have to deal with complex, concealed structuring and an array of potential plays (Appendices 3, 4). The possible source rocks are only exposed peripherally to the region and while various reservoir rocks or conditions can be conceived none of these are exposed.

The confirmation of one seep also meant that some of the other reported occurrences might also be true seepages. As these cover a wide area and could all be consistent with an Ordovician

source than the original licence areas, held or applied for, were much too small if the potential of the basin were to be properly assessed and results protected.

Thus by the end of 1986 it had been established that at least one true seepage existed and that the composition of the hydrocarbons was consistent with a limestone source. Further, the conodont studies of the Gordon Limestone had shown that the unit was currently within the oil window in southeastern Tasmania. This was quite in accord with other evidence which had suggested that the unit may have been a source rock; residual tars and pitches have long been known elsewhere in the state, and the writer had proposed this very play concept to another company in 1982 - alas without the support of an analysed seepage. Other reported seepages had to be taken seriously, relocated and tested. Meanwhile it was decided to apply for the region west of Bruny Island which appeared to contain most of the reported seepage sites (52/86 and 53/86). Suspected sites occur at Adventure Bay, Glenlusk, Grove and Cygnet as well as in sea bed muds (Volkman, Appendix 2).

Is the limestone of the Gordon Group the only possible source? The discovery of an Upper Cambrian limestone on the south coast may yet be significant. Preliminary results of recent analyses of both limestones are given in Appendix 6. All confirm that these units are within the oil window. Total organic content levels are consistent with surface exposed carbonates.

At this stage, however, it must be presumed that three possible source rocks may exist within the region: Permian shale or correlate, and Ordovician and Cambrian limestones.

Present work indicates that the Gordon Limestone is the most likely SOURCE rock; oil was generated, could have been reservoired and some, at least, remains to feed the seepage.

Some comment must be made about the possible Permian source. Recent release of analyses of Tasmanites oil shale (e.g. Baillie, 1987) has led to suggestions that Conga's result is comparable. This view is not accepted by Dr. Volkman or the writer on present evidence but other seepages are being sought and further, less contaminated, samples of the original seepage have been submitted for analysis. These tests should settle the question since the oil shales possess unique biomarkers.

Possible RESERVOIRS include Silurian sandstones if present, the limestone itself, karsts at the base Permian unconformity and basal conglomerates.

Possible SEALS include Ordovician or Silurian shales, Permian mudstone/tillite or even dolerite. Structural TRAPS may include folds, unconformities, fault/unconformity offsets and dolerite intrusions (see Appendices 3 and 4). Some of these factors, and indeed the preservation of hydrocarbons in any event, depend on the AGE OF GENERATION. Leaman (Appendix 3) argues for a Jurassic-Cretaceous generation and that this area has suffered little subsequent Cainozoic disruption.

All the ingredients for a successful oil exploration programme are present. Sources in the oil window, a range of possible seals and traps, a feasible thermal history AND at least one proven seepage. Few virgin basins offer such indications before the first round of drilling.

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Recognition that the source rocks might be deeply buried (>> 1 km), patchy and yet widespread beneath the unconformity at the base of the Permian rocks (Parameener Super Group) meant that geophysical methods must be used extensively during any exploration programme. It was realised that the extent of the possible Lower Palaeozoic basin and structuring was unknown and all available geophysical data was examined. The results are presented as Appendix 3. In order to properly appraise the content of then newly pegged ELs 52 and 53/86 a wide area was studied.

The results suggested that a large region was structured and that Cambrian rocks, at least, were present in abundance. A rock distribution like that along the Dundas Trough or west of Maydena seemed probable.

On the basis of this study of rather scrappy data it was decided to apply for the entire region east of the Palaeozoic and Precambrian exposures at, or west of, the Picton River. Applications 8/87-14/87 resulted and meant that methods could be used which would trace structures and rock units from exposure into the area of greatest interest. Gravity and magnetic methods had already shown themselves viable and it was decided to provide a uniform high standard aeromagnetic survey and then infill the existing gravity data base before winter.

At this stage only one licence had ever been granted and its renewal was delayed and not guaranteed (29/84). Action to instigate surveys was thus courageous or foolhardy depending on one's viewpoint but there is no doubt that the decision has greatly accelerated exploration and understanding of the region. Data applicable to EL 29/84 from these surveys is included in Appendix 5. Compilation maps for the surveys are presented (Figures 2 and 3) but, as explained in the introduction, the raw total data bases remain proprietary and the company is under no obligation to release them since the work has the standing of private research undertaken before granting of licences.

The exploration thinking developed by Leaman and Burrett (Appendices 1 and 3) was independently vetted (Mulready, Appendix 4) and found to be reasoned and convincing. Although Appendix 4 is restricted to discussion of EL 29/84 its implications are more widely cast even if the conclusions are not. Mulready rates one stratigraphic well as sufficient to appraise this small area but the exploration area is very much larger. It was admitted that the exploration might be long term, difficult and frustrating.

An early emphasis had been placed on the use of gravity and magnetic methods. This reflected availability of data and the likely problems and costs associated with seismic surveys.

In April 1987 the writer, having been technical consultant for some months, was appointed to act as exploration manager in order to streamline and guide the operation. This was not a full time position.

The problem of seismic data has weighed heavily on the project given the desire of the partners to drill at an early stage. The area does not lend itself to regional coverage (terrain, environment, cost) and reflection methods have yet to be established in these conditions. Tests (Leaman, 1978) and Richardson and Leaman (1981) showed that surface conditions and dolerite may severely degrade signals. In good conditions, however, Leaman (1978) did demonstrate clear reflectors in records up to 4 seconds long. A test programme has been designed to develop optimal specifications in these conditions. A survey of the water covered areas has been suggested and costed which would provide the essential background regional view but this has yet to be approved.

Until seismic data can assist or support the programme the gravity-magnetics data base will be fully utilised. This means that the level of interpretation reached must be well beyond industry norms for these methods and their present day use in oil exploration. While it is appreciated that these methods may never provide the prospect detail desirable every effort will be made to extract as much structural detail as can be resolved.

The role of seismic methods has yet to be finalised but advance budgets have allowed for marine regional coverage and moderate prospect resolution surveys designed and located on the basis of the gravity-magnetics work. Unfortunately, due to early management decisions, the first well will probably be drilled without the benefit of any seismic data or establishment of the feasibility of seismic coverage and will be based only on preliminary interpretations of other methods. This may be sufficient for a purely stratigraphic well, as defined in Appendix 4, but there is no guarantee that such a well will be ideally placed for this purpose. This risk would pertain, to some extent, even if some seismic data were available since the reflection response pattern of the section is quite unknown at this stage.

Preliminary field work and interpretation has suggested that additional seepages may occur in the Collinsvale region and that structures inferred further south persist into this area. Licence 46/87 was requested in June 1987 on the basis of these early indications.

All interpretive work leading to the siting of the first well will be reported in the next annual report. It is incomplete at the time of preparation of this review.

As noted above the first well is planned for an early stage of the exploration programme. Conga Oil will drill using its own rig, capable of 4000 m holes, acquired from the United States and has appointed a drilling supervisor (Mr. E.M. McNally).

PROGRESS TO DATE:

1. The reported seep near Johnson's Well on North Bruny Island has been relocated and the material analysed. The results are regarded as preliminary (Appendix 2)
2. A primary study of hydrocarbon potential in the region south of Hobart has been completed. This has shown rocks of the Ordovician Gordon Group to be within the oil window (Appendices 1, 6).
3. Feasible structural plays have been reviewed and an exploration programme developed to resolve them (in Appendices 3, 4).
4. Sufficient area has been claimed in order to allow sensible investigation of all probable source-reservoir options and to ensure coverage of potentially long migration paths within the region.
5. A regional basin study using pre-existing geophysical and thermal data has been completed. This lacked usable seismic data but showed that gravity and magnetic methods can make a significant, cost effective contribution (Appendix 3).
6. Specifications for aeromagnetic, gravity and marine reflection programmes have been provided (Appendix 3). No specifications have yet been recommended for onshore seismic surveys.
7. An aeromagnetic survey of the entire claimed area and a gravity survey infill of the region from the Hartz Mountains to Storm Bay have been completed. See Figures 2, 3. (This item has not been costed against any licences not granted at the time of survey)
8. Completion of an appraisal of the play concepts and proposed methodology (Appendix 4).
9. Establishment of drilling regulations and acquisition of rig for the purpose of drilling Conga's wells or independent contracting.

PROGRAMMES IN PROGRESS:

1. A seep search programme has been commenced to locate all other reported sites and obtain samples. If other sites can be confirmed and some patterns established between seepage sites and structural interpretations it is believed that problems of target priorities will be greatly eased. This programme will ultimately include both sea bed and land searches and complete analyses of recovered samples. It is hoped that this work will resolve the issue of the source rocks and whether different source conditions pertain across the region. K.C. Morrison Pty Ltd has been engaged for the land search.
2. A detailed structural interpretation of the gravity-magnetics data base is underway which should provide orientation guidance for seismic surveys and a general view of the basin as well as suggesting structure and prospect patterns within it. The initial stratigraphic well will be based on the preliminary stage of this work.
3. Source rock sampling and analysis.
4. Review of basement lithologies and distribution as revealed by content of Permian tillites and basal conglomerates, and Tertiary pyroclastics. This study is designed to support the development of basement composition studies derived from regional geophysical data until adequate regional seismic cover and drill control become available. The results may be used in association with the seepage study and the first phase of regional interpretation to site the initial well.

PROGRAMMES PROPOSED:

1. A regional stratigraphic and palaeontologic compilation to assist well sample identifications.
2. A sea bed sampling programme to support the onshore seepage location programme. Location of any anomalous hydrocarbons in the sea bed muds may be relevant to target and structure appraisal. To be undertaken by CSIRO.
3. A trial onshore seismic programme to establish method feasibility, costs, specifications and problems. To be undertaken by Mines Department, scheduled for Oct. 1987.
4. An initial well for stratigraphic and geophysical control purposes. Now scheduled for January 1988.
5. A regional marine gravity and seismic coverage of the D'Entrecasteaux Channel, Huon Estuary and western part of Storm Bay. Gravity data are needed to overcome the problems posed by the dubious character of the existing gravity data base east of Bruny Island.

These programmes fulfill Mulready's recommendations (Appendix 4). Recommendations 1 to 4 already completed.

SUMMARY OF EXPLORATION OBJECTIVES

The present programme is not restricted by any assumptions or presumptions about the pre-Permian geology of the region but the following essential facts have emerged.

1. A structured and variable pre-Permian sequence exists.
2. Two source rocks have already been demonstrated (Ordovician and Cambrian) and a third (Permian) may exist on a very local basis.
3. Hydrocarbons have been reported and one seepage, at least, appears likely to be confirmed absolutely (Appendix 4).

The region can not be written off without a thorough evaluation of the distribution of the source rocks and possible traps/reservoirs since there is potential for significant hydrocarbon recovery in such an environment. The exploration may not be easy as Mulready notes in Appendix 4 but it is clearly worth doing and should be afforded every encouragement in view of Tasmania's economic climate.

Issues to be evaluated include:

SOURCES:

Acquire further data on organic content of possible source lithologies including parts of the Permian. Such data to be contrasted with any seep results. There is a need to define any dominant source or establish if sources are localised or multiple.

ASSESS SCALE OF GENERATION OR MIGRATION:

This problem is partly related to the nature of the source. However, any distribution of seepages or source indications upon analysis of such seepages will be critical. It is hoped that these indicators might be tied to inferred lithology distribution as suggested from the geophysical or pyroclastic studies.

Present limited work suggests that there may be a correlation between reported (not necessarily confirmed) seeps and dolerite feeders. This might suggest that limited generation occurred around the feeder from any source or that the feeder fracture system is allowing vertical escape from a source unit or reservoir. In such a case little migration may be involved, or there may be lateral migration to the feeder system. These ambiguities could conceal either large or small volumes of hydrocarbon and each possibility must be tested decisively.

PLAY DEFINITION:

Preliminary work to date suggests the presence of fold closures, rejuvenated troughs, unconformity seals, shelf deposition, rift margin rise shoulders and dolerite traps. Each of these feature styles will need to be defined, rated and drilled. Rating will be affected by inferred rock distributions and migration considerations and seismic data is likely to be essential to such appraisals. The economics and practicability of seismic methods has yet to be established in this environment.

OVERALL:

To evaluate the region in such a way as to rationally assess its potential for Conga's purposes or to aid future explorers.

EXPENDITURE SUMMARY

The table below is applied to the set of licences as if consolidated. The present figures are unduly biased by management and other overhead costs such as licence fees since most licences have been acquired during the period covered by this report and the full work commitment has not yet been applied to such areas. Only EL 29/84 has applied for the full year and the purely technical component of the summary is such that its commitments have been exceeded. The table is thus not a reliable guide to the expenditure proportions which will prevail in a settled, complete year.

Geology (regional appraisals, seep search, feeder location, consultants, etc).....	\$11055.52
Geochemistry (analyses).....	700.00
Geophysics (regional study, data acq 29/84, interpretation in progress).....	26320.00
Drilling.....	0.00
Administrative overheads (licence fees, accounting, management).....	40935.00
Staff (Drilling engineer, assts).....	21480.00
	Total: 100490.52

Expenditures to Aug 15, 1987.

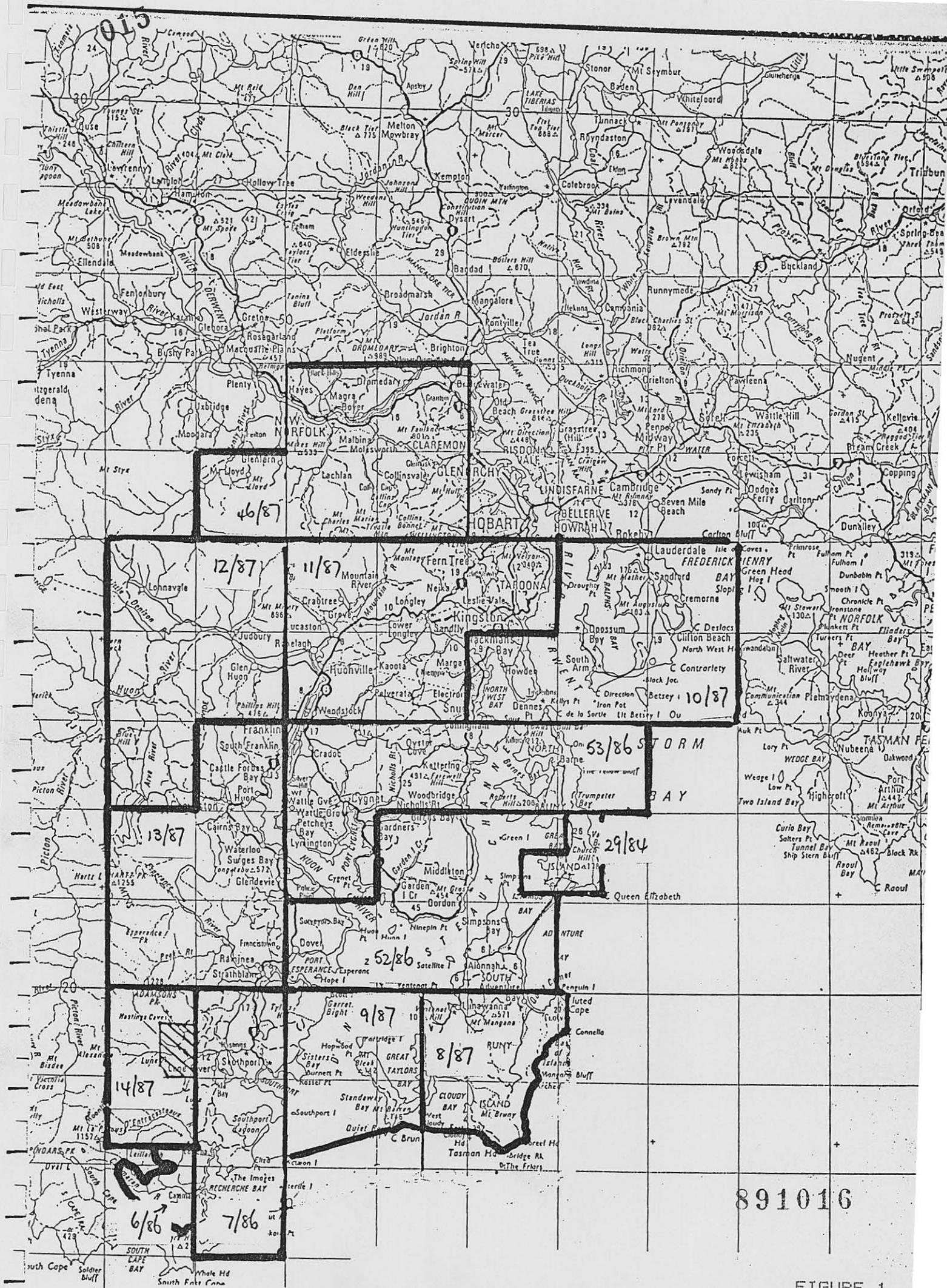
REFERENCES

Baillie, P.W., 1987. Petroleum geochemistry of a sample of Tasmanites oil shale. Unpub. Rep. Dep. Mines Tasm., 1987/28.

Leaman, D.E., 1978. Use of the reflection method in Tasmania. Part i. Geophysics special report, Dep. Mines Tasm.

Leaman, D.E., and Naqvi, I.H., 1967. Geology and geophysics of the Cygnet District. Bull. geol. Surv. Tasm., 49.

Richardson, R.G., and Leaman, D.E., 1981. Fingal Tier reflection traverses 1 and 2. Unpub. Rept. Dep. Mines Tasm., 1981/6.



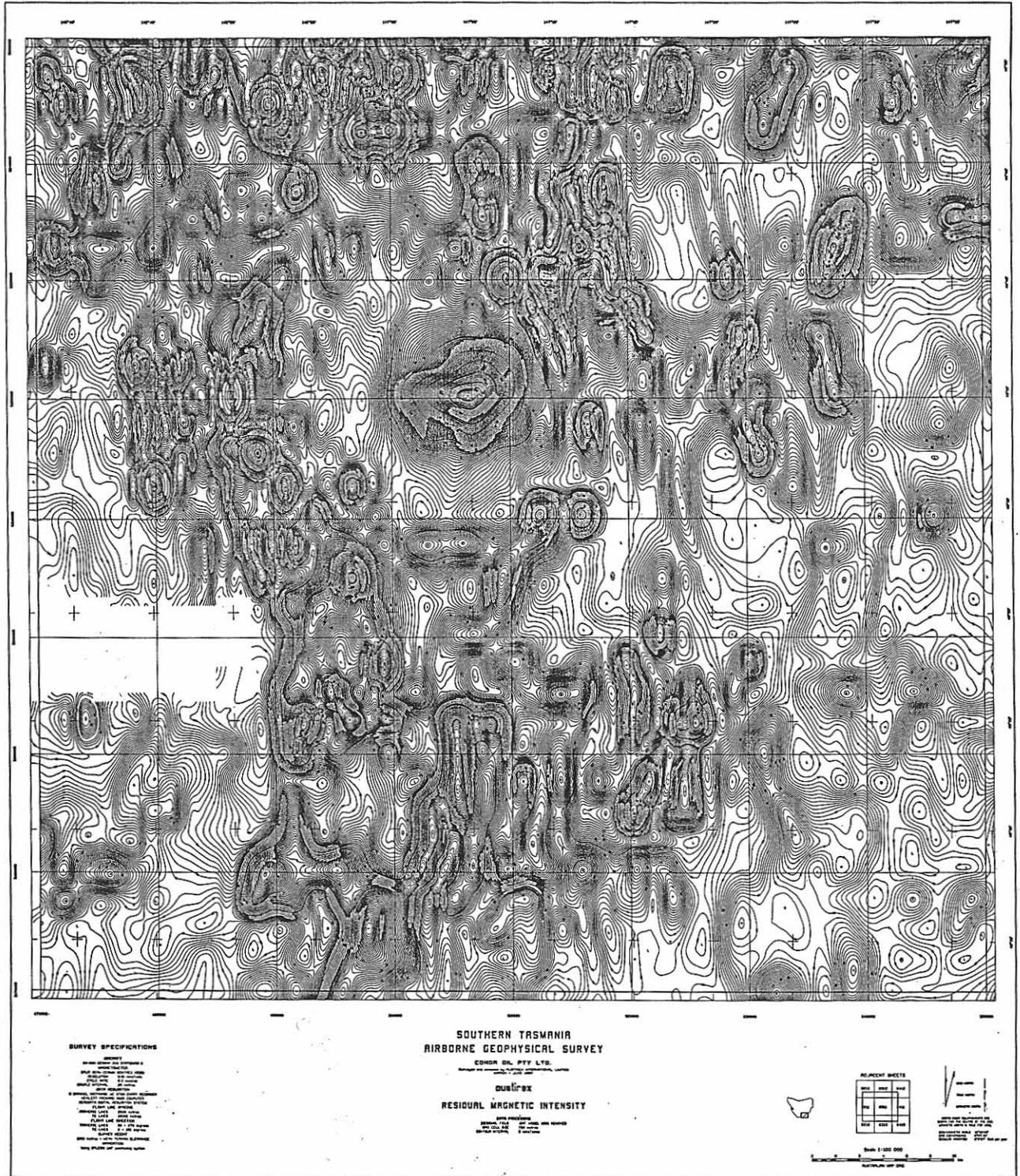
891016

FIGURE 1

SURVEY AREA AND LOCATION OF EXPLORATION LICENCES

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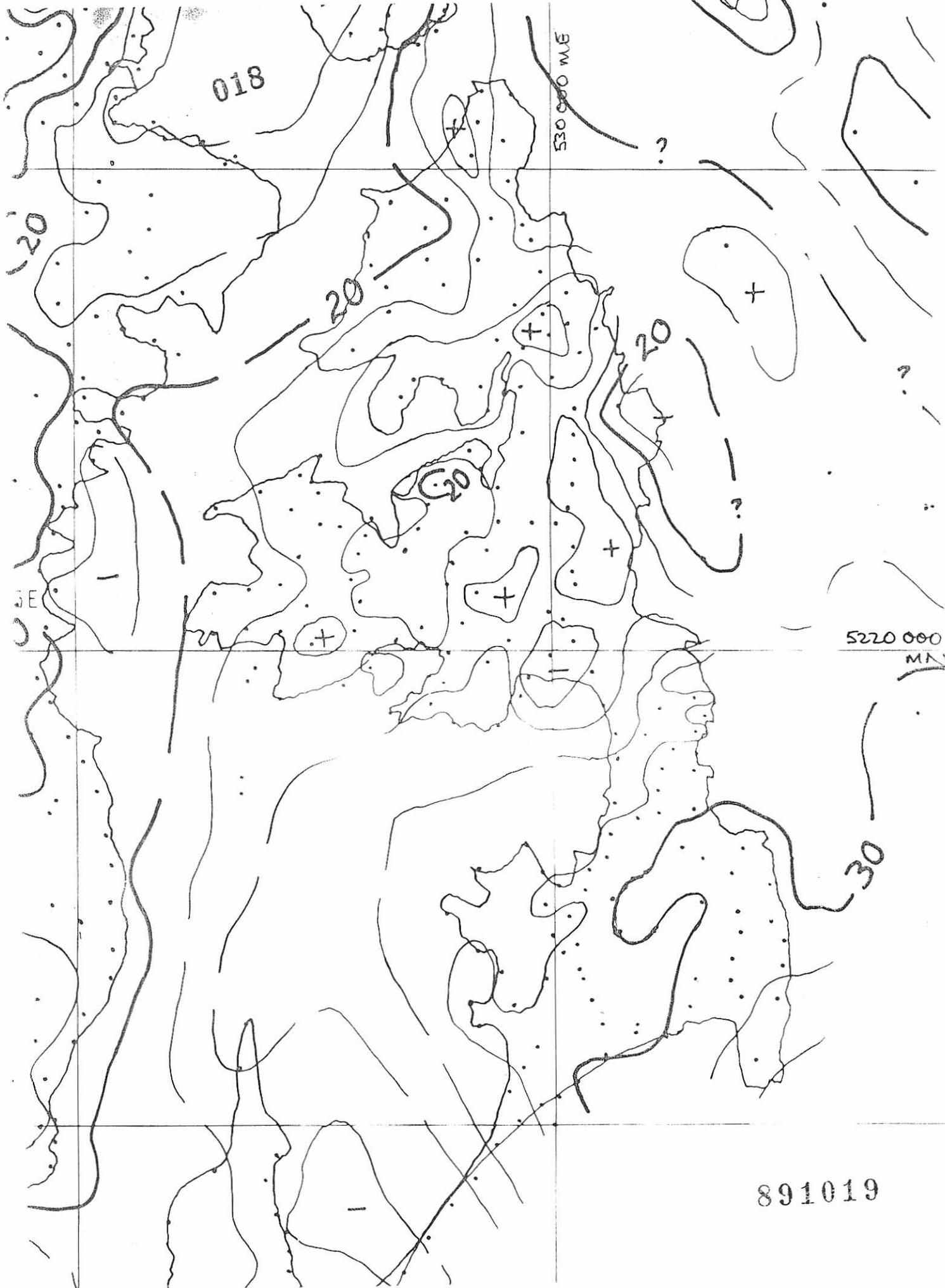
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5 cm

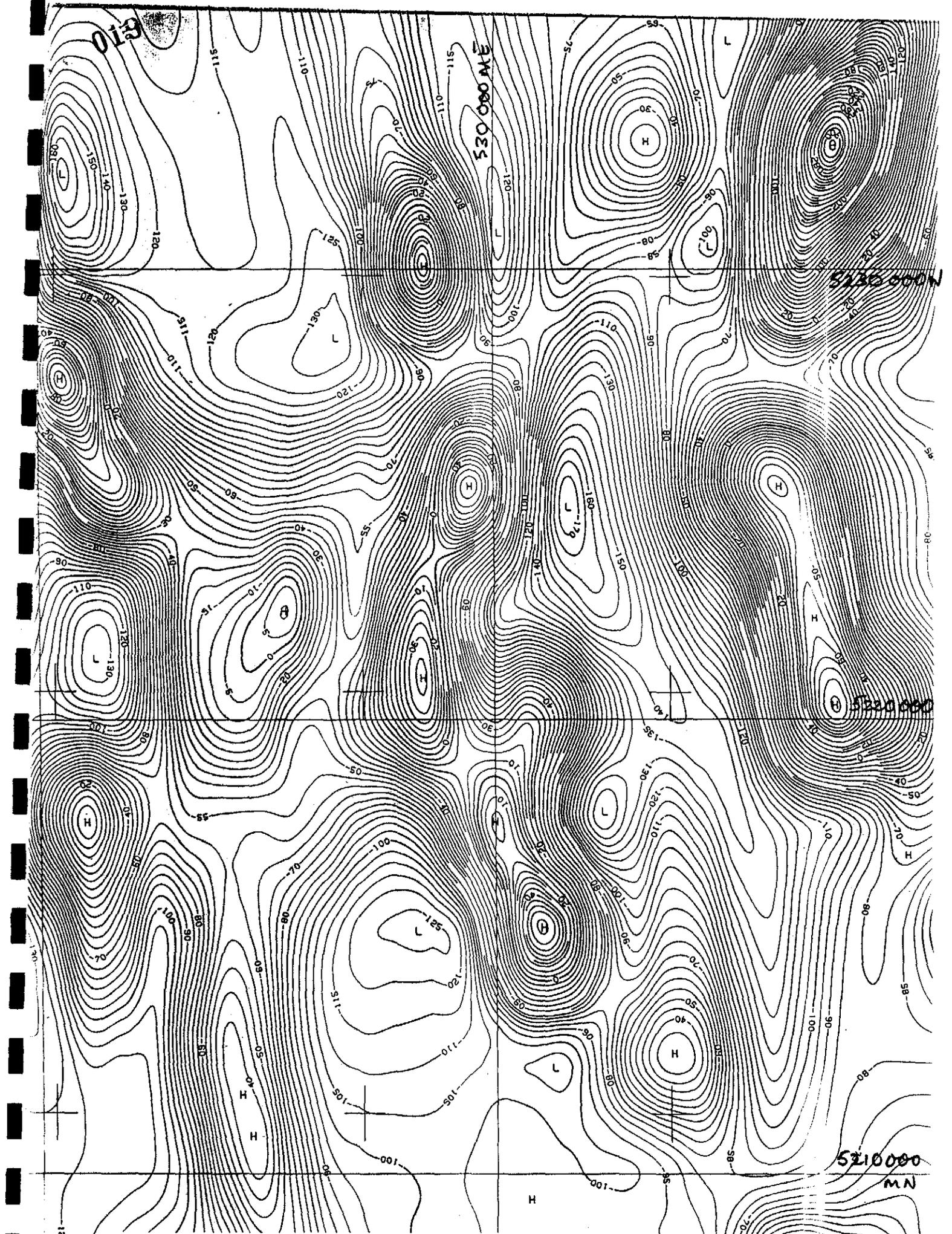
COMPILATION: D'ENTRECASTEAUX AEROMAGNETIC SURVEY (1000 m elev)
Acquisition: Austirex, 1987.

FIGURE 3



DETAILED PLOT OF GRAVITY FIELD, NORTH BRUNY ISLAND (EL 29/84)

FIGURE 4



DETAILED PLOT OF MAGNETIC FIELD, NORTH BRUNY ISLAND (EL 29/84)
 Data at 1000m elevation.

020

530 000 ME

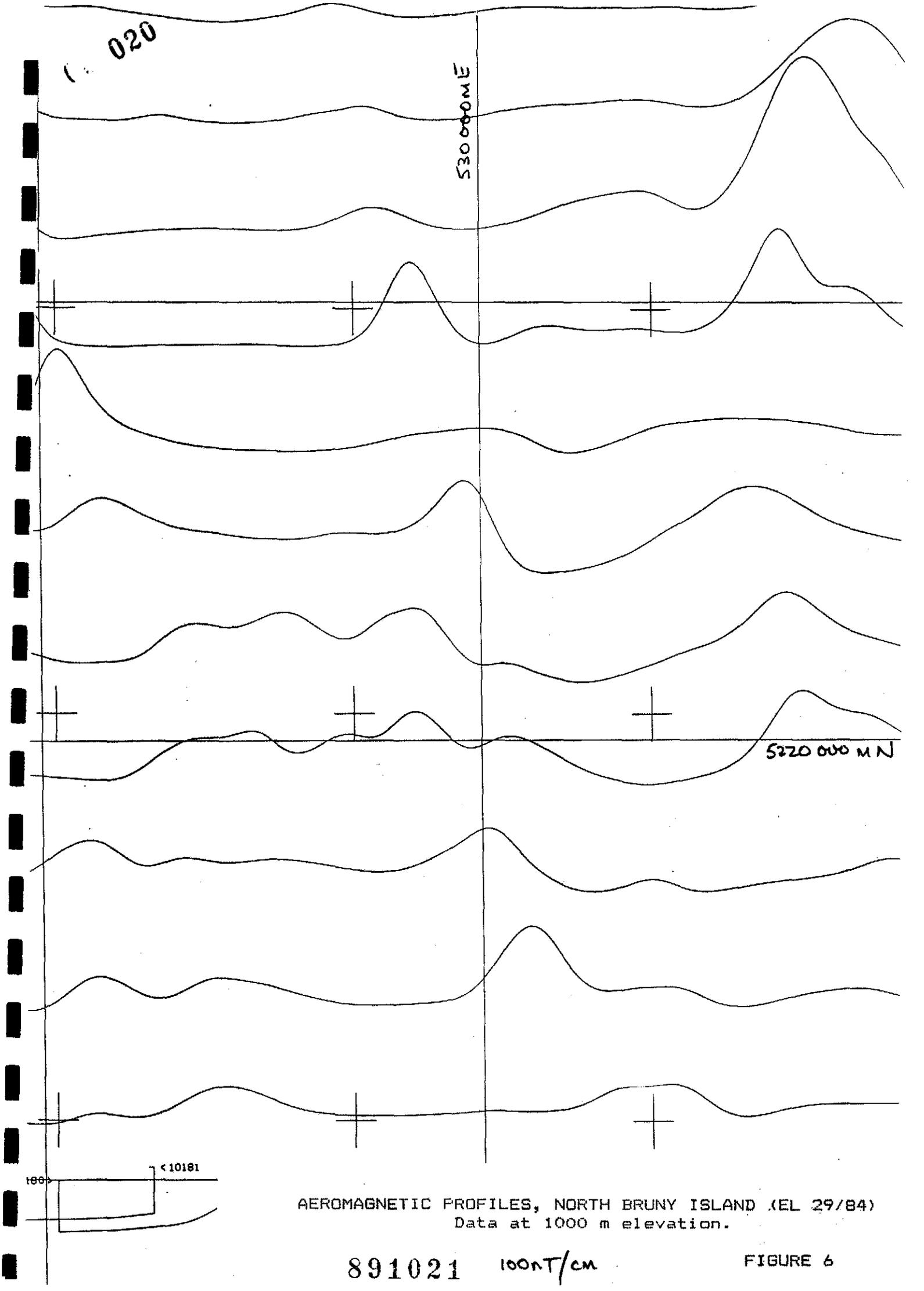
5220 000 M N

< 10181

AEROMAGNETIC PROFILES, NORTH BRUNY ISLAND (EL 29/84)
Data at 1000 m elevation.

891021 100nT/cm

FIGURE 6



021

891022

Appendix
1

PETROLEUM PROSPECTIVITY OF CENTRAL SOUTHERN TASMANIA

- A PRELIMINARY REPORT

BY DR. CLIVE F. BURRETT

GEOLOGY DEPARTMENT, UNIVERSITY OF TASMANIA.

SUMMARY

Possible source rocks occur as organic rich shales and nodular carbonates beneath suitable reservoirs (platform margin buildups) in the Ordovician of Central South Tasmania. On the basis of the conodont Colour Alteration Index (CAI) much of the ordovician carbonate sequence is in the oil window (CAI of 1.5-2) and could, if intersected, beneath suitable seals (which exist in the Parmeener Supergroup) be prospective for hydrocarbons. The prospectivity of the area is degraded by the existence of extensive and often unpredictable diabase sills and associated dykes, by widespread (mainly) Tertiary faults and the unknown extent of post-Devonian-pre-permian erosion. A stratigraphic well sited northwest of Catamaran should intersect the potential ordovician reservoir rocks beneath a few hundred metres of Permo-Triassic and possibly Silurian siliciclastics and will provide the information necessary to determine if further investigations are warranted.

INTRODUCTION

Oil exploration was initiated in this area (Fig.1) in 1909 when the government geologist (W.H. Twelvetrees) was commissioned to investigate oil seeps and shows along the South Coast. Very little work was done in the area until B.H.P. Company geologists compiled a map of the area based on rapid helicopter reconnaissance. Intensive geological work was initiated by the writer and colleagues in the late 1970's who concentrated mainly on the Ordovician Limestone sequence (Burrett et al 1981, 82, 84). Unpublished theses dealing with the area and surrounding regions include Davidson (1969), Correy (1983) and Sharples (1979). Bruny Island has been studied by Rigg (1970), Clark (1972) and Farmer (1985).

GENERAL GEOLOGY

A Precambrian quartzite-dolomite sequence is overlain by a Cambrian submarine fan complex with minor carbonates. These are overlain by an Upper Cambrian - Lower Ordovician siliciclastic sand sequence and then by shales and shaley nodular carbonates of Lower Middle Ordovician age (Karmberg Limestone correlate). These in turn are conformably overlain by oncolitic algal carbonates (Cashions Creek Limestone correlate). These are overlain by about 130m of massive carbonates and 230m of micrites and shales of Upper Ordovician age (Fig.3). These are overlain by a few tens of metres of siliciclastics of the Upper Ordovician - Silurian Eldon Group. Folding along N - S trending axes occurred during the Early Devonian with some minor overthrusting towards the east.

The base of the Parmeener Supergroup is usually a fillite of variable thickness that rests with marked landscape unconformity on the Lower Palaeozoic strata. This basal Upper Carboniferous fillite is overlain by a sequence of glacio-marine shales and sandstones of Permian age (Figs. 2 & 8). These are succeeded by an Upper Permian coal-bearing sequence (the Cygnet Coal Measures) and are in turn overlain by the dominantly fluviatile sandstones and shales of the Triassic Upper Parmeener Supergroup.

Extensive and often transgressive (Davidson 1969) sills of dolerite (diabase) intruded during the Jurassic (Fig.4) mainly into the Parmeener Supergroup. The unpredictable nature of the dolerite makes drilling hazardous as dolerite sills or dykes may be intersected unexpectedly at depth. Dolerite sills now forms most of the high ground in the area. Metamorphism is localised in the vicinity of the sills, though where there is a combination of sill and dyke (for instance along the New River) contact metamorphism may be more extensive.

at Precipitous Bluff and at Mr. Bobs.

The area was extensively faulted during the Tertiary and possibly in the Jurassic.

ORDOVICIAN PALAEOGEOGRAPHY

Due to the discovery of low Conodont Colour Alteration Index (CAI) values in much of the Gordon Group Limestone, the Ordovician rocks of this area are of interest from a hydrocarbon point of view.

During the Ordovician, the sea gradually transgressed from the east and south over the gradually eroding Precambrian-Cambrian rocks of the Tyennan Block of Western Tasmania. The resultant Tyennan Island or archipelago was, by the Middle Ordovician (Blackriveran) surrounded by broad tidal flats now represented by algal-laminated dolomitic micrites such as those at Ida Bay, (Burrett et al 1984). From information at localities at Mt. Bobs, Judds Cavern, Picton River, Precipitous Bluff, Pt. Cecil, Surprise Bay and Ida Bay, the broad pattern of lithofacies can be mapped (Fig.5). The extension of these M. Ordovician lithofacies to Bruny Island is not known. Deeper water (650m) lay to the south and the platform was rimmed by coralline platform margin buildups (Fig. 6A). During the Upper Middle Ordovician ("Trentovian") the angle of depositional slope changed and a rimmed platform (Fig.6B) was transformed into a ramp with a consequent inland (northward) migration of the fringing coralline buildups. In the Upper Ordovician and Lower Silurian well sorted quartz arenites were deposited due to a rise in sea levels to the west (Correy 1983).

PERMIAN PALAEOGEOGRAPHY

The area was near to the western depositional margin of the Tasman Basin during the Permian (Fig.7). As a result many of the units recognised in the basin depocentre (north of Hobart) are either thinner or absent in this area (Clarke in press). Little work has been done on the Permian of the area, what little is known is summarised in Fig. 8. The lower part of the sequence (the Woody Island Formation) is a suitable source rock but is unlikely to have been buried sufficiently to be (or have been) generating hydrocarbon unless there is (or was) an (unexpectedly) steep geothermal gradient in the area.

SOURCE ROCKS

Suitable source rocks are present in the Karmbez Limestone (and underlying shales if present) in the Precipitous Bluff Beds, in the unnamed Mid-Ordovician lagoonal carbonates of the Vanishing Falls area and in the shales and siltstones of the lower Parmeener Supergroup. No bio geochemical work has been carried out on any of these sediments.

ORGANIC MATURATION

The possible Ordovician source rocks are, within much of the area, within the oil window on the basis of the Conodont Colour Alteration Index (CAI) (Fig.9-10).

CAI's of 1.5-2 are present in carbonates for the Picton River, Vanishing Falls, Surprise Bay and Ida Bay. There is a propability that potential source rocks are (or were) in the oil window beneath Parmeener Supergroup rocks. It is unlikely that potential source rocks within the Parmeener are at a sufficient depth to have genented hydrocarbons though in areas of high geothermal gradient - for instance near Hastings, near the Cretaceous syenite at Cygnet or adjacent to the pervanne dolerite, local heating may have produced oil and gas. Such local heating may well be the source of the gas reported by Mr. Bendall on North Bruny Island. Mr. Steve Forsyth (in Farmer 1986) reports that the palynomorphs for the Parmeener Supergroup of the Cygnet area are carbonised. This is probably due to heating associated with the Cretaceous allealine intrusions. Chitinozon from the Ordovician of the Salisbury River are reddish-brown in colour which indicates an 'Oil window' maturation index and agrees with the CAI values of the conodonts.

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RESERVOIRS

Potential reservoirs with relatively high porosity (15%) and adequate permeability may exist in the Eldon Groups (Silvrian) siliciclastics overlying the limestone sequence in the calcaremic upper parts of the Ordovician limestones and in some of the sands of the Parmeener Supergroup. The excellent reservoir characteristics of coeval and similar Permian glaciomarine and glaciofluvial siliciclastics in the Evomanga Basin of Australia and in Southern Oman are now well known. However, few porosity / permeability measurements have been carried out on any of these rocks and the potential reservoir characteristics of these units is based on thin-section estimates only. Direct measurements on core samples are clearly needed.

RECOMMENDATIONS

The extent of the dolerite on Bruny Island (Clark 1972) makes selection of a drilling site on that Island difficult. The problems of predicting basement in this area also make Bruny Island unattractive. Potentially, more productive areas occur on the mainland where suitable sections of Permian Supergroups probably overlie potential reservoirs and sources in the Eldon and Gordon Groups. A site located on a track at grid ref. DM 889781 and outside of the National Parks boundary is indicated on Fig. 5. and in appendix 1 (1:100 000 Map S.E. Cape). These sites would be expected to pass through a few hundred metres of Triassic Sandstone, about 600m. of Permian siliciclastics, about 50m of Eldon Sandstones and then about 600m of Ordovician carbonate thereby intersecting all likely reservoirs.

REFERENCES

- Burrett, C.F., Laurie, J & Stait, B., 1981. Gordon Subgroup (Ordovician) carbonates at Precipitous Bluff and Point Cecil, Southern Tasmania, Australia. Papers Proc. Roy.Soc.Tasm.115:93-99.
- Burrett, C.F., Stait, B. & Laurie, J., 1982. Trilobites and microfossils from the Middle Ordovician of Surprise Bay, Southern Tasmania, Australia. Mem. Ass. Australasian Palaeontols. 1 : 177-193.
- Burrett, C.F., Stait, B. Sharples, C. & Laurie, J., 1984. Middle Upper Ordovician Shallow platform to deep basin transect, Southern Tasmania, Australia. In Bruton, D. (Ed.) Aspects of the Ordovician System 149-157. Universitets Oslo.
- Clarke, C.J. 1972. A Gravity Survey of Bruny Island Unpublished Thesis. Univ. Tasmania. 57pp.
- Clarke, M.J., 1978. Lower Parmeener Supergroup. In Burrett, C.F. (Ed.) Geology of Tasmania Blackwells, Melbourne. in press.
- Correy, J.J., 1983. The geology of the Mt. Bobs-Boomerang area, S.E. Tasmania. Unpublished thesis, University, Tasmania. 170pp.
- Davidson, J.K. 1969. Upper Permian and Lower Triassic of the La Perouse area. Unpublished thesis, Univ. Tasmania. 108pp.
- Farmer, N., 1985. Kingborough. Tasmania Dept. Mines. Explanatory Report. Geological Atlas. 1:50,000. 105pp.
- Rigg, A.J., 1970. Permo-Triassic Stratigraphy, Sedimentation and Palaeontology of South Bruny Is. Unpublished thesis Univ.Tas.141pp.
- Sharples, C. 1979. Geology of the Ida Bay area. Unpublished thesis. University of Tasmania. 175pp.

032

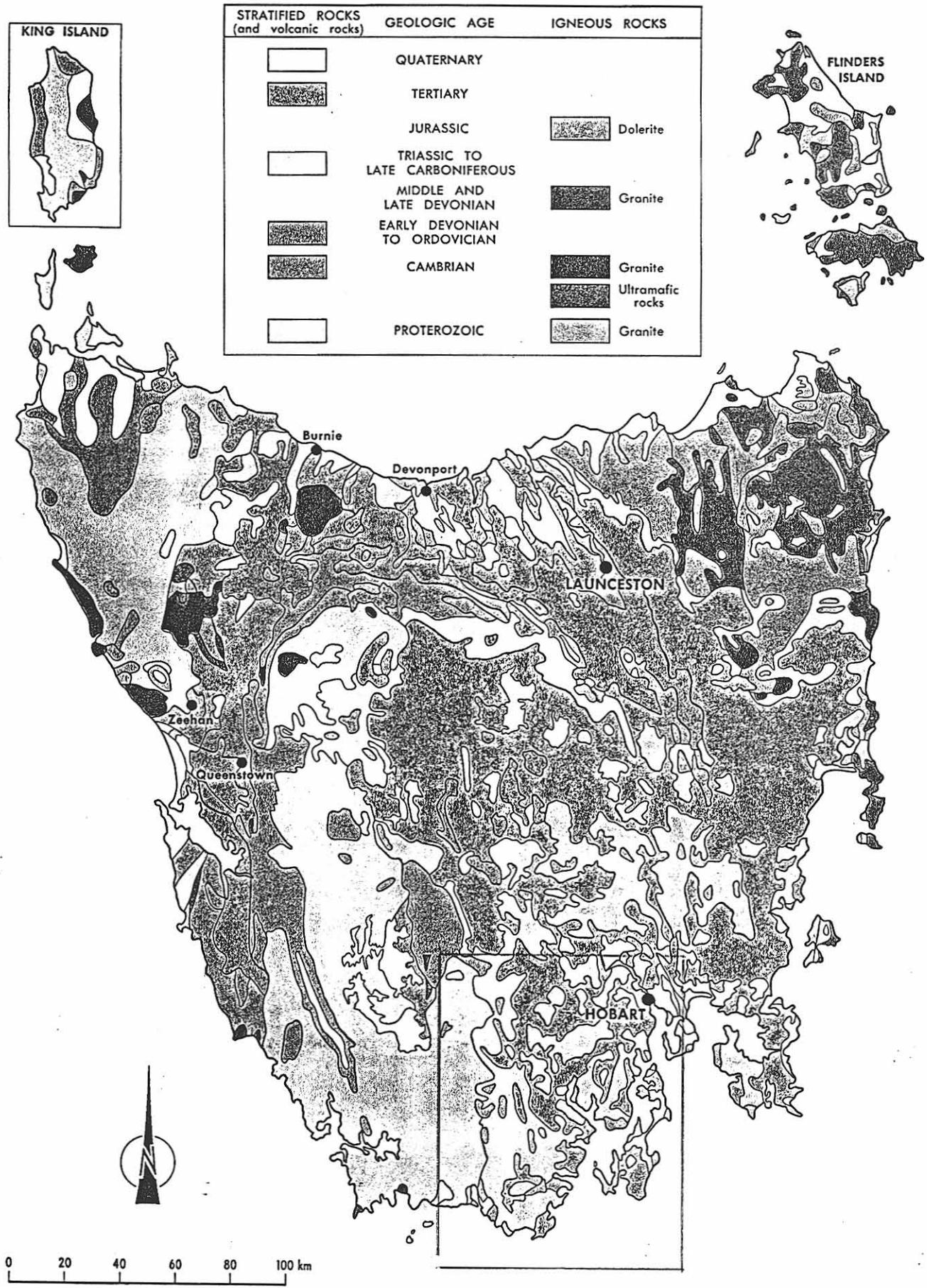
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SHARPLES, C. 1979. GEOLOGY OF THE IDA BAY AREA
UNPUBLISHED THESIS. UNIVERSITY
OF TASMANIA. 175pp.

033 FIG. 1. GENERALIZED GEOLOGY OF TASMANIA.

891034

AREA CONSIDERED IS INDICATED BY RECTANGLE.



Drawn by Cartographic Section, Geological Survey Branch, Department of Mines, Hobart

0 20 40 60 80 100 km

5 cm

034

FIG. 2. GENERALIZED STRATIGRAPHIC COLUMN FOR SOUTH CENTRAL TASMANIA.

LITHOSTRATIGRAPHIC UNIT		LITHOLOGY	ECONOMIC CHARACTER	AGE
PARMEENER SUPERGROUP	UPPER 300M	Quartz Arenites Lithic Wackes	Suitable Seals	TRIASSIC
	LOWER 300M	Coals Glacio-Marine Silt, Shales and Sandstones tillite		Possible source rock (immature)
	ELDON GROUP 40M	Quartz Arenite	Possible reservoir	UPPER ORD - LOWER SIL
GORDON GROUP	PRECIPITOUS BLUFF BEDS 230M	Shales and Micrites	Possible Source Rock	UPPER ORDOVICIAN
	NEW RIVER BEDS 380M	Platform margin calcarenite and Calcirudites	Possible Reservoir	UPPER MIDDLE ORDOVICIAN (BLACK RIVERAN)
	CASHIONS CREEK 150M	Algal Limestone	Possible Source Rocks	LOWER MIDDLE ORDOVICIAN
	KARMBERG 100M	Nodular Limestone		
DENISON GROUP		Quartz Arenites		LOWER ORDOVICIAN
		Turbidites		CAMBRIAN
		Dolomites Quartzites		PRE CAMBRIAN

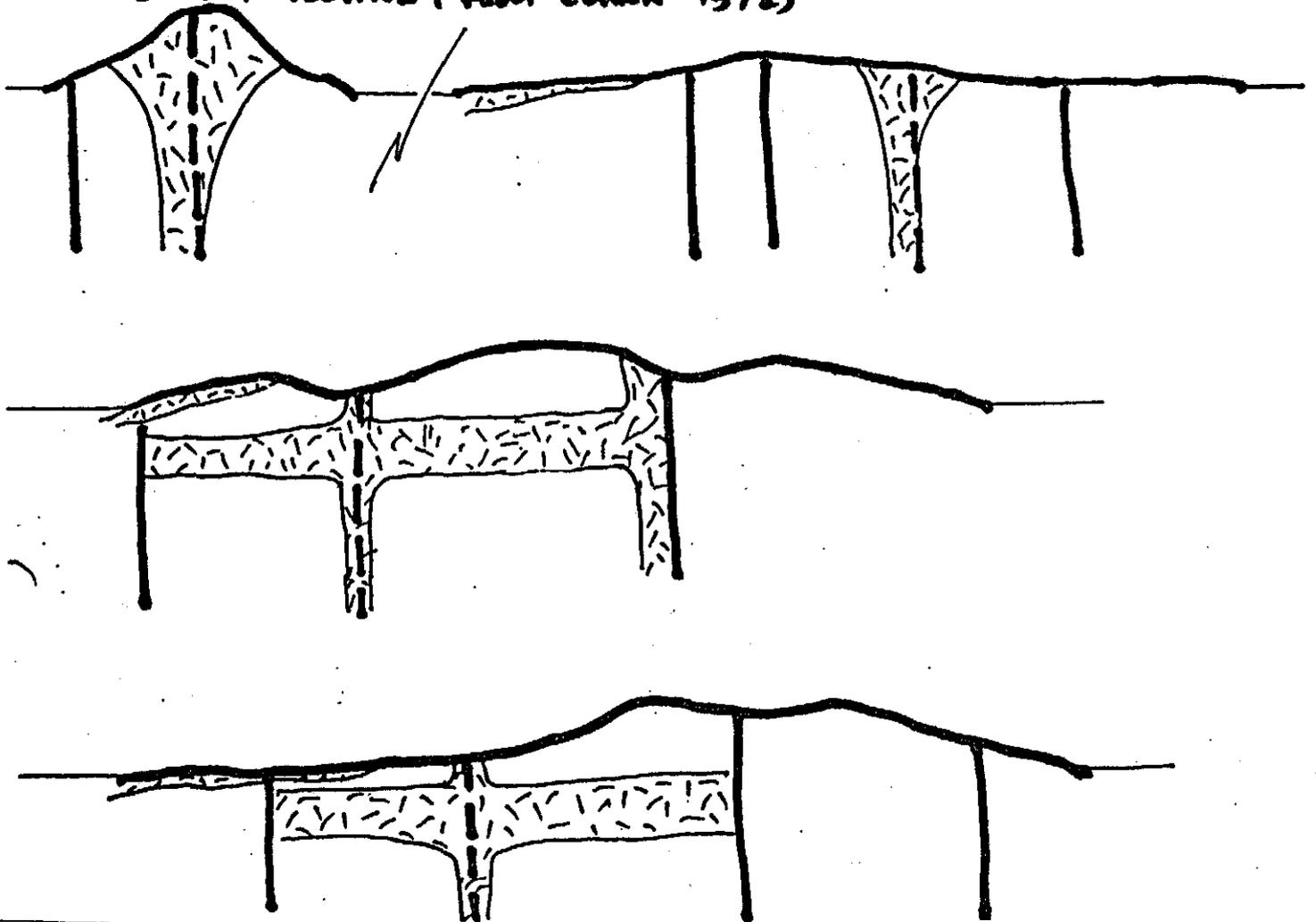
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FIG. 3. STRATIGRAPHIC COLUMN OF GORDON GROUP CARBONATES AT
PRECIPITOUS BLUFF.

FIG. 4. EXTENT AND FORM OF DOLERITE (DIABASE) INTRUSIONS ON BRUNY ISLAND (FROM CLARK 1972).

EXTENT AND FORM OF DOLERITE (DIABASE) INTRUSIONS ON BRUNY ISLAND (FROM CLARK 1972)



5. LITHOFACIES MAP OF THE MIDDLE MIDDLE ORDOVICIAN (BLACKRIVERAN) BASED ON INFORMATION FROM ALL OUTCROPS.

A POSSIBLE DRILLING SITE IS INDICATED.

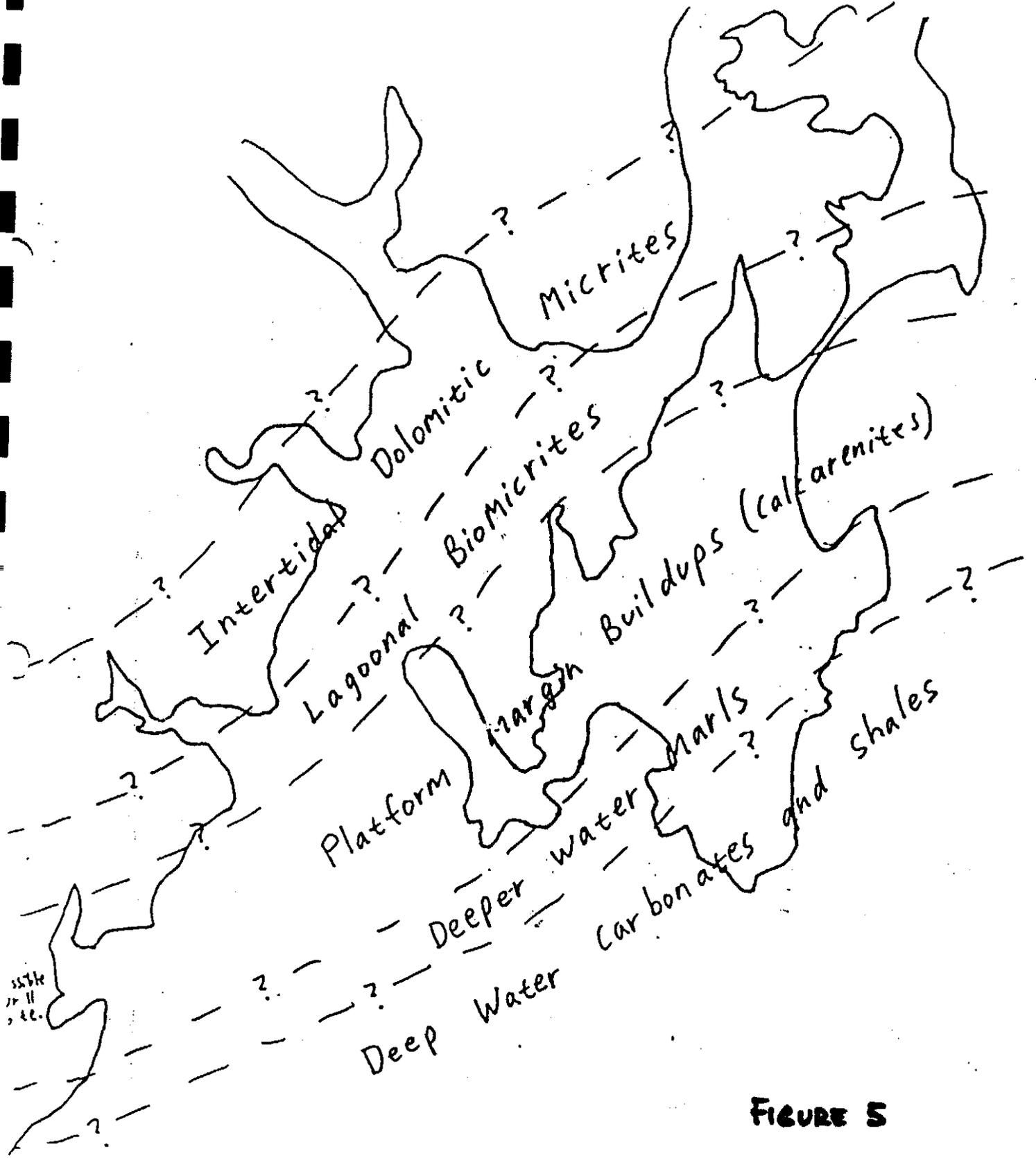
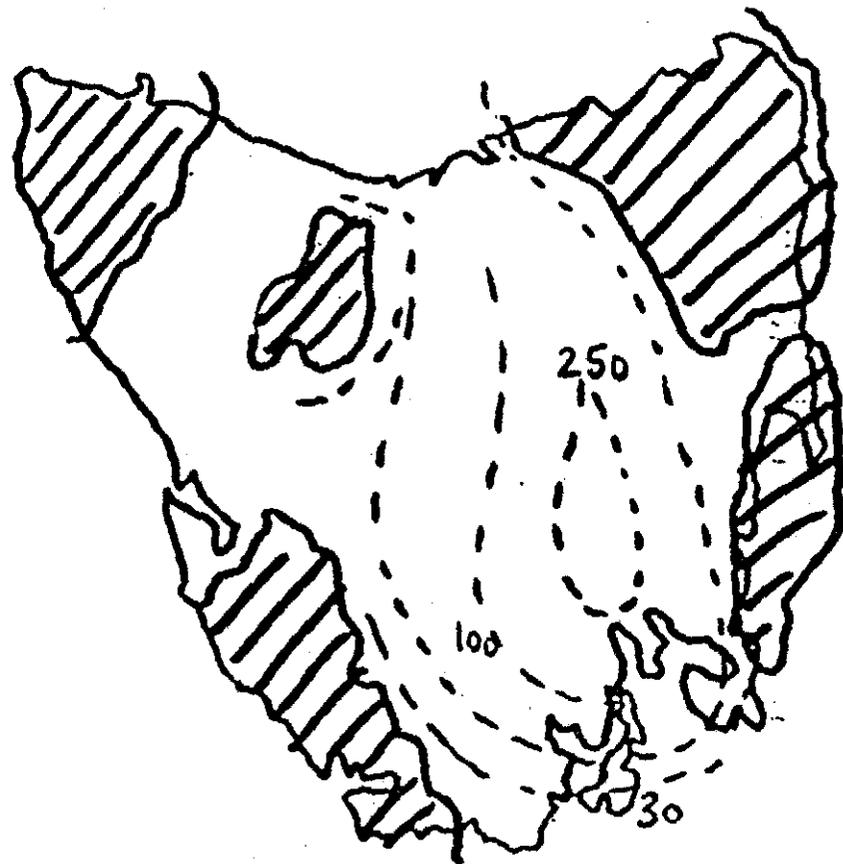


FIGURE 5

FIG. 7. PALAEOGEOGRAPHIC MAP FOR PART OF THE
LOWER PERMIAN. FROM CLARKE (IN PRESS).



/// LAND

--- isopachs (m)

Correlation diagram of six lithostratigraphic columns through the lower part of the Parmeener Super-Group in south-east Tasmania

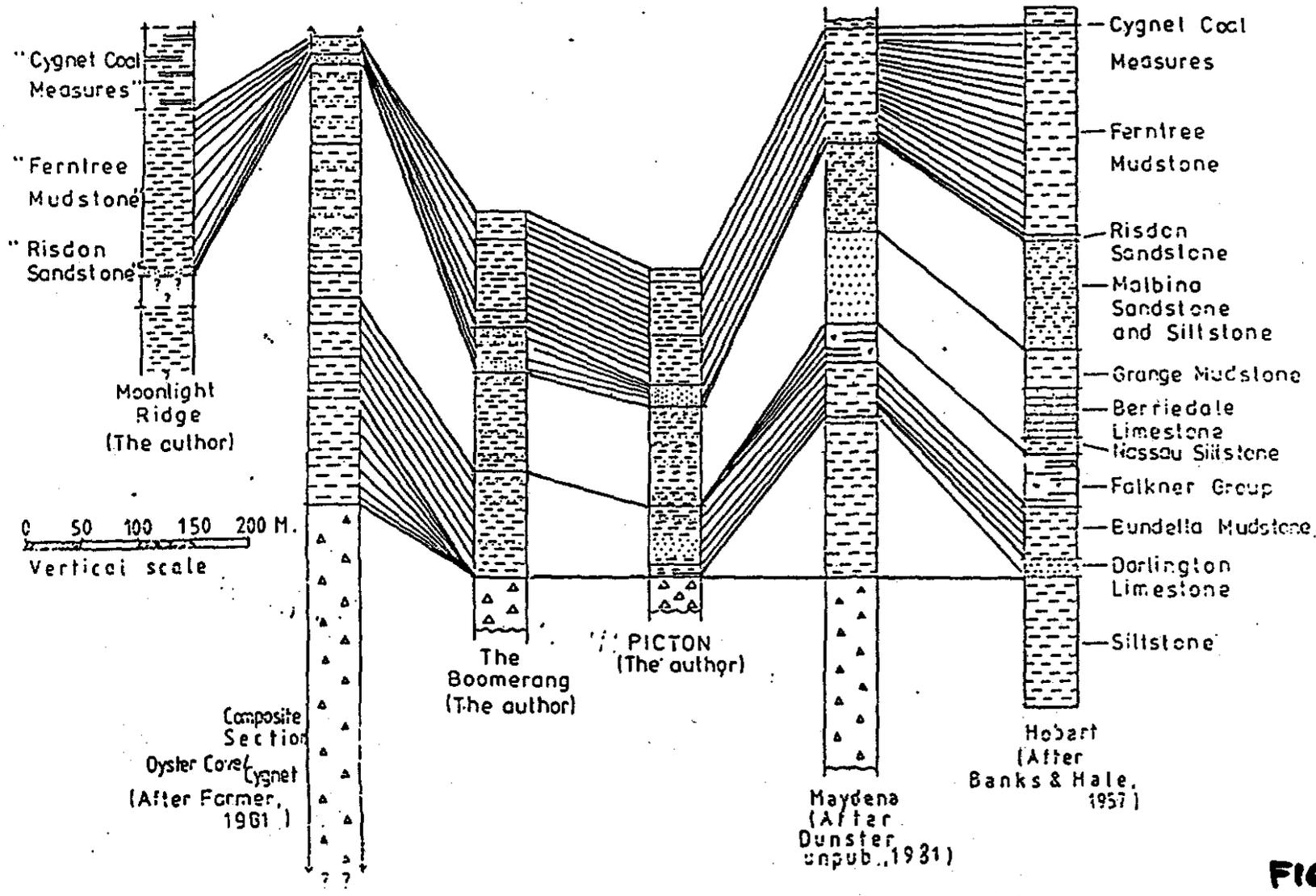


FIG. 8. STRATIGRAPHIC COLUMNS FOR THE LOWER PARMEENER SUPERGROUP. (UPPER CARBONIFEROUS - PERMIAN) SOUTH CENTRAL TASMANIA. FROM CORREY (1983).

FIGURE 8

FIG. 9. CHART SHOWING ORGANIC MATURATION INDICES INCLUDING THE CONODONT COLOUR ALTERATION INDEX (CAI).

CHART OF ORGANIC MATURATION

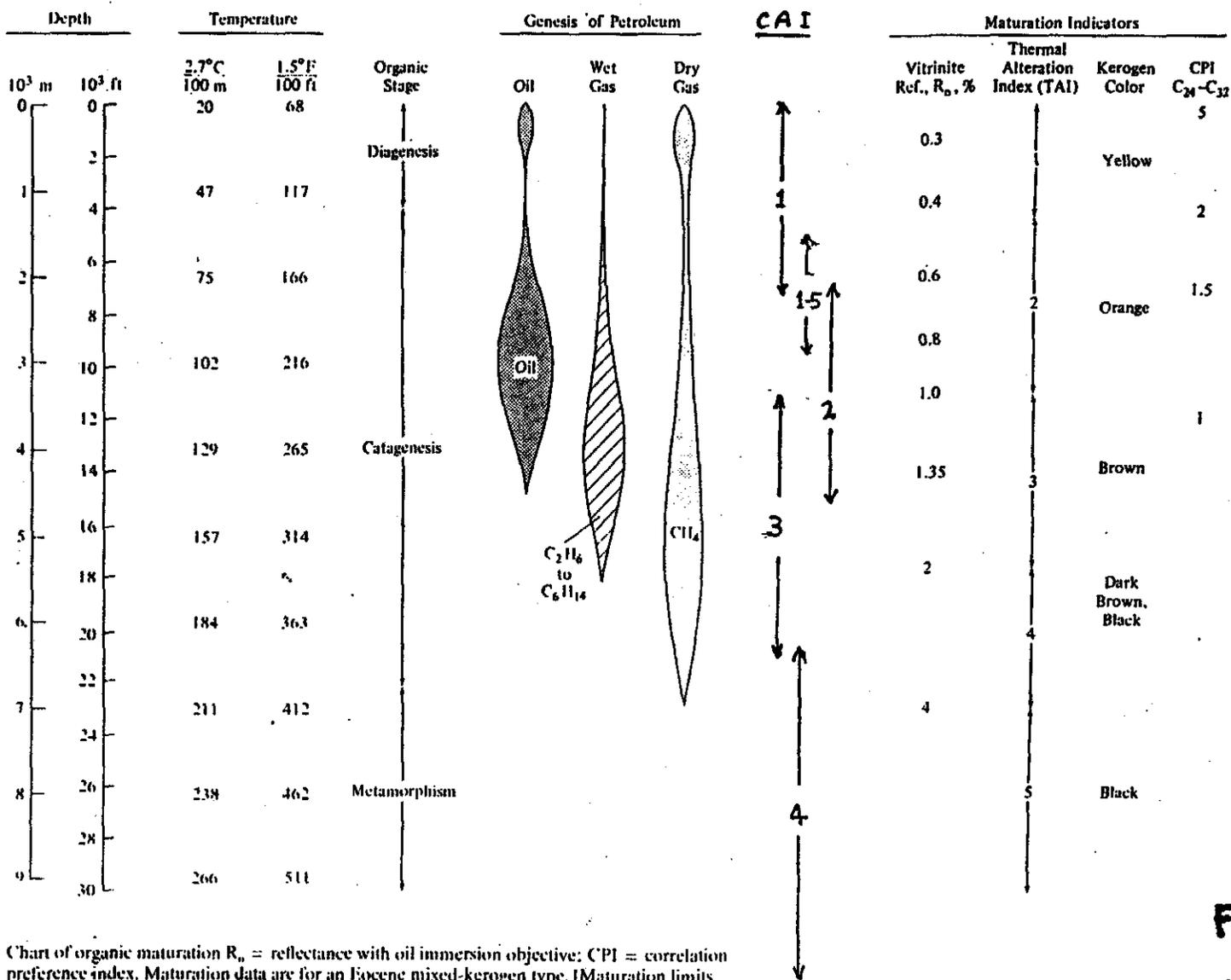
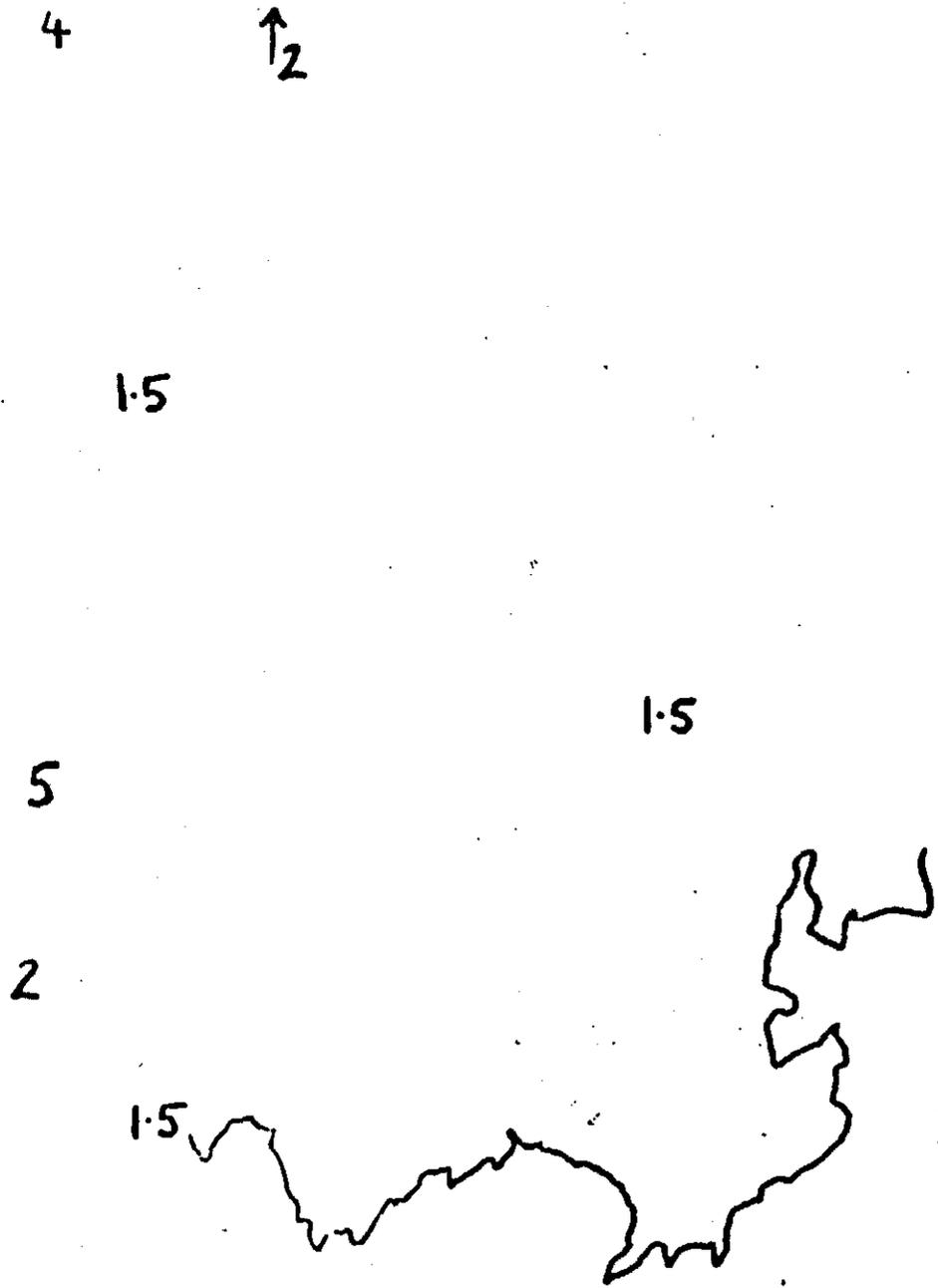


Chart of organic maturation R_o = reflectance with oil immersion objective; CPI = correlation preference index. Maturation data are for an Eocene mixed-kerogen type. [Maturation limits from Dow 1977a; Staplin 1969; Teichmüller 1974]

Fi
(H)

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10 CONODONT COLOUR ALTERATION INDEX
FOR ALL ORDOVICIAN CARBONATE
OCCURRENCES. HIGH VALUES IN THE
WEST ARE DUE TO PROXIMITY TO A
DOLERITE FEEDER DYKE.
BURRETT (UNPUBLISHED).



891043

Appendix 2

042

CSIRO**MARINE LABORATORIES**

Division of Fisheries Research
Division of Oceanography

Castray Esplanade, Hobart, Tas. 7000

A Division of the Institute of Animal and Food Sciences
A Division of the Institute of Physical Sciences

GPO Box 1538, Hobart, Tas. 7001
Telephone (002) 20 6222 Telex AA 57182
Facsimile (002) 23 7125

April 13th, 1987

Dr. D. Leaman
Consultant Geophysicist
Leaman Geophysics
G.P.O. Box 320D
Hobart
Tasmania 7001

Dear David,

I much appreciated your visit this morning to inform me of latest developments regarding proposed oil drilling on Bruny Island by Conga Oil.

As you now know, my only interaction with Mr. Bendall has been to assist him in the interpretation of organic geochemical data obtained on a mud sample from Bruny Island which he believed contained petroleum residues originating from an oil seep. I presume that my advice was sought since I have experience in the application of organic geochemistry techniques to petroleum geochemistry and I have published quite a few scientific papers in this field. Such expertise seems to be sadly lacking in Tasmania so I was happy to assist Mr. Bendall in this way.

I think that it is important to document my main findings concerning the geochemical data for the oil seep sample obtained by Analabs in Perth, so that there can be no misunderstanding about the information that I gave Mr. Bendall. My interpretation is limited by the fact that I was not involved with the collection of the oil seep sample, nor did I carry out the geochemical analyses. You should also be aware that the sample was not very suitable for organic geochemical analysis due to the low amounts of hydrocarbons present and high proportion of biologically produced hydrocarbons. Analyses of such materials can be very difficult to interpret due to possible changes in oil composition during migration, and subsequent biodegradation where the oil comes to the surface.

My main findings are:

(1) The mud sample contains a mixture of hydrocarbons, most of which are derived from vascular plants. However, the gas chromatogram of the saturates does show the presence of shorter-chain alkanes with no odd-over-even predominance, together with pristane and phytane that are more commonly associated with petroleum. Stereochemical analysis of the isoprenoids would be needed to confirm their petrogenic origin.

(2) Biomarker analyses of this sample by Analabs using gas chromatography-mass spectrometry also shows evidence of recent biogenic hydrocarbons superimposed on a distribution of steranes and hopanes that are from a thermally mature source. These compounds are quite minor components of the extractable hydrocarbons, but their presence is consistent with an oil seep. I agree with the suggestion by Analabs based on sterane ratios that the maturity of the presumed source of this petroleum corresponds to a vitrinite reflection of about 0.75 (i.e. well into the oil window).

(3) An unusual feature of the distributions of biomarkers is the presence of a series of alkyl cyclohexanes. These are abundant in only a few oils, and it has been noted that they appear to be associated with Ordovician carbonates or evaporitic facies. However, this is not proof that the petroleum originated from a carbonate sequence. The GC-MS data provided by Analabs is limited to a single m/z 83 mass fragmentogram with only one compound identified in the series so I would like to see further work done to confirm these identifications. These data should then be compared with those obtained for presumed source rocks to confirm the source of the oil.

(4) The presence of hydrocarbons covering a wide range of molecular weights including both short-chain alkanes, alkyl cyclohexanes and high boiling steranes and triterpanes is consistent with a crude oil rather than a refined petroleum product. Mr. Bendall assures me that there is no possibility that this petroleum could have originated from human activity, such as a farmer dumping sump oil or other petroleum product, but it would be prudent to analyze other seep samples to confirm that the hydrocarbons are not from pollution.

(5) Analabs reported high concentrations of aromatic hydrocarbons in the mud sample. Naturally produced aromatic compounds can be found in sediments but high concentrations of aromatics are usually due to pollution or petroleum residues. These aromatic hydrocarbons should be characterised by gas chromatography-mass spectrometry to see whether the distributions are consistent with inferences drawn from the saturated alkanes. Parameters are now available to determine the maturity of the oil based on the proportions of methyl phenanthrene isomers.

(6) These preliminary data are thus consistent with an oil seep, but additional samples from this site and other seeps on Bruny Island and surrounding areas should be studied to confirm this. Care should be taken to exclude plant matter from the sediment sample (e.g. by sieving) since biogenic hydrocarbons from this source are much more abundant than petrogenic hydrocarbons in the

sample that I looked at. It is apparent from the high noise level in some of the mass fragmentograms produced by Analabs that they had difficulty in detecting some of the petroleum biomarkers and they were not able to calculate all the biomarker parameters that are usually included in a geochemical assessment of a petroleum sample. I also feel that it would be wise to establish the geographic distribution of oil seepage before a concerted drilling program is undertaken.

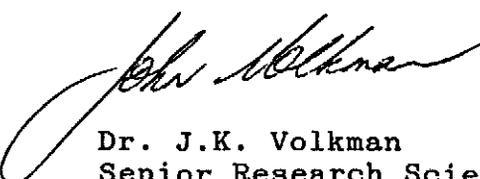
I stress that the geochemical data obtained to date are not adequate to characterise the source of the petroleum hydrocarbons found in the mud sample from Bruny Island.

As mentioned in our discussions, staff from my research group in the CSIRO Division of Oceanography and a student from the University of Tasmania have been undertaking a small project studying the organic constituents of sediments from D'Entrecasteau Channel to determine the relative contributions from seaweeds, phytoplankton, and terrigenous material etc. To our surprise, some of these sediments were found to contain petroleum hydrocarbons. It is possible that these originate from oil seeps but we have not yet done a detailed comparison with the material from Bruny Island. Preliminary work suggests that these samples do not contain significant amounts of the alkyl cyclohexanes found in the Bruny Island material. We still need to do further work to characterise the hydrocarbon distributions, and to establish whether these originate from pollution or from oil seeps.

It might be useful in the future to undertake a sampling program to assess how widespread these occurrence are. This would involve collecting grab samples of sediments in waters off Bruny Island and analysis for hydrocarbons by gas chromatography. Any samples that contained suspected petroleum hydrocarbons would then have to be analysed by gas chromatography-mass spectrometry. The Division of Oceanography has all the necessary equipment for these analyses and I have the expertise to interpret the data. However, such analyses are not part of our main research program so they could only be undertaken on a cost-recovery basis.

I hope that this information is of use to you in relation to petroleum exploration plans for this area.

Your sincerely,



Dr. J.K. Volkman
Senior Research Scientist
CSIRO Division Of Oceanography

copies to:

Dr. A. D. McEwan, Chief, CSIRO Division of Oceanography
Mr. B. Jackson, Divisional Secretary
Mr. M. Bendall, Director, Conga Oil Pty. Ltd.

046
ANALABS

a Division of Macdonald Hamilton & Co. Pty. Ltd.
ANALYTICAL CHEMISTS

• PERTH:
52 MURRAY ROAD,
WELSHPOOL, WESTERN AUSTRALIA, 6106
TELEPHONE (09) 458 7999
TELEX: ANALAB AA 92560
P.O. BOX 210, BENTLEY, W.A. 6102

BHK/fmh

10th November, 1986.

Mr. M. Bendall
Conga Oil Pty Ltd
84 Wells Parade
BLACKMANS BAY TAS 7152

Dear Mr Bendall,

Please find enclosed the results of solvent extraction, liquid chromatography and C_{12}^+ saturate chromatography as performed on your mud sample.

The GC trace is dominated by higher plant waxes which are represented by the high peaks between n- C_{22} and n- C_{31} . This plant material is not believed to be part of hydrocarbons present in the sediment but rather represents roots and other fresh plant parts present in the mud sample.

The range between C_{12} and about C_{20} however might characterize n-alkanes (paraffins) which are actually part of hydrocarbons in the clay.

If you do intend to go ahead with the investigation, I would suggest to obtain a sample for headspace (C_1 - C_7 components) gas analysis. In this case the sample has to be in a sealed container (tinned can) as these hydrocarbons are highly volatile. The tin should be 2/3 filled with sample and covered completely with water, with a headspace of at least one inch above the water level. This headspace is necessary to allow the collection of escaping gases. Bactericide should be added to prevent bacterial generation of methane during storage.

If you have any queries concerning these results, or if we may be of further assistance, please do not hesitate to contact us.

Yours faithfully,

B. Hartung-Kagi

BIRGITTA HARTUNG-KAGI
Manager - Oil & Gas Division

encs:

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ANALABS

A Division of Macdonald Hamilton & Co. Pty. Ltd.

ANALYTICAL CHEMISTS

• PERTH:
52 MURRAY ROAD,
WELSHPOOL, WESTERN AUSTRALIA, 6106
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P.O. BOX 210, BENTLEY, W.A. 6102

BHK/lnh

11th December, 1986.

Mr M Bendall
Gonga Oil Pty Ltd
84 Wells Parade
BLACKMANS BAY TAS 7152

Dear Mr Bendall,

Please find enclosed the results of gas chromatography-mass spectrometry as performed on your mud sample from a Tasmanian gas seep.

GC-MS provides information about the thermal history of the sediment, depositional environment, type of organic matter and possible biodegradation, based on the distribution of biological markers (biomarkers) in the samples. A correlation of different oils or oils and source rocks is often possible with this method.

The term 'biomarker' is used to describe those compounds in sediments which have an obvious structural relationship with biologically produced compounds. Useful biomarkers are e.g. hopanes, moretanes and steranes.

The extract recovered from your mud sample contains very small amounts of steranes. Unfortunately this makes it impossible to determine the source type of the organic matter by sterane and diasterane distribution. It is, however, possible to use sterane and triterpane maturity parameters. Hopanes and steranes indicate somewhat different levels of maturity, a fact which could be explained by a mixture of recent plant material present in the sample and mature hydrocarbons. C_{30} hopane/ C_{30} moretane and C_{31} 22S/22R hopane ratios characterize an extract from an immature mud, whereas the C_{29} 20S/20R sterane and the Ts/Tm ratio are indicative for fairly mature hydrocarbons. The C_{29} 20S/20R sterane value in particular is believed to be equivalent to about 0.75% Ro, which means well within the oil window (Approx. 0.6 - 12.0%).

As the steranes occur at such a low level in this sample, the analytical procedure was repeated with the same result as before. That means, the sample appears to contain fairly mature hydrocarbons, which could be interpreted as having migrated into the mud sequence, together with immature organic matter probably derived from recent plant debris.

APPENDIX

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Drimanes and rearranged drimanes occur in both samples. They are common C₁₅ and C₁₆ bicyclic compounds in oils and believed to characterize microbial activity in sediments.

Gas chromatography to be performed on the aromatic fraction of the extract is in progress and the results will be forwarded to you on completion. This GC will probably give a clearer picture of the maturity level of the organic matter contained in the mud sample.

If you have any queries concerning the above, please do not hesitate to contact us.

Yours faithfully,

Birgitta Hartung-Kagi
BIRGITTA HARTUNG-KAGI
Manager - Oil & Gas

049

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TABLE 1

Summary of Extraction and Liquid Chromatography

Wellname: UNKNOWN

Date of Job: NOVEMBER 1986

A. Concentrations of Extracted Material

Sample	Weight of Rock Extd. (grams)	Total Extract (ppm)	Loss on Column (ppm)	-----Hydrocarbons-----			-----Nonhydrocarbons-----		
				Saturates (ppm)	Aromatics (ppm)	HC Total (ppm)	NSO's (ppm)	Asphaltenes (ppm)	NonHC Total (ppm)
Gas Seep Mud Sample	124.9	703.0	551.6	11.2	32.0	43.2	108.1	nd	108.1

TABLE 1

Summary of Extraction and Liquid Chromatography

Wellname: UNKNOWN

Date of Job: NOVEMBER 1986

B. Compositional Data

Sample	-----Hydrocarbons-----			-----Nonhydrocarbons-----			EDM(ng) TOC(g)	SAT(ng) TOC(g)	SAT/ ARDM	ASPH NSO	HC/ Non HC
	ZSAT.	ZARDM.	ZHC's	ZNSO's	ZASPH.	ZNon HC's					
Gas Seep Mud Sample	7.4	21.2	28.6	71.4	nd	71.4	nd	nd	.35	nd	.4

na = not applicable nd = no data

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TABLE 2

Summary of Gas Chromatography Data

Wellname: UNKNOWN

Date of Job: NOVEMBER 1986

A. Alkane Compositional Data

Sample	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21+C22)/(C28+C29)
Gas Seep Mud Sample	2.00	.58	.35	3.02	3.98	.21

TABLE 2

Summary of Gas Chromatography Data

Wellname: UNKNOWN

Date of Job: NOVEMBER 1986

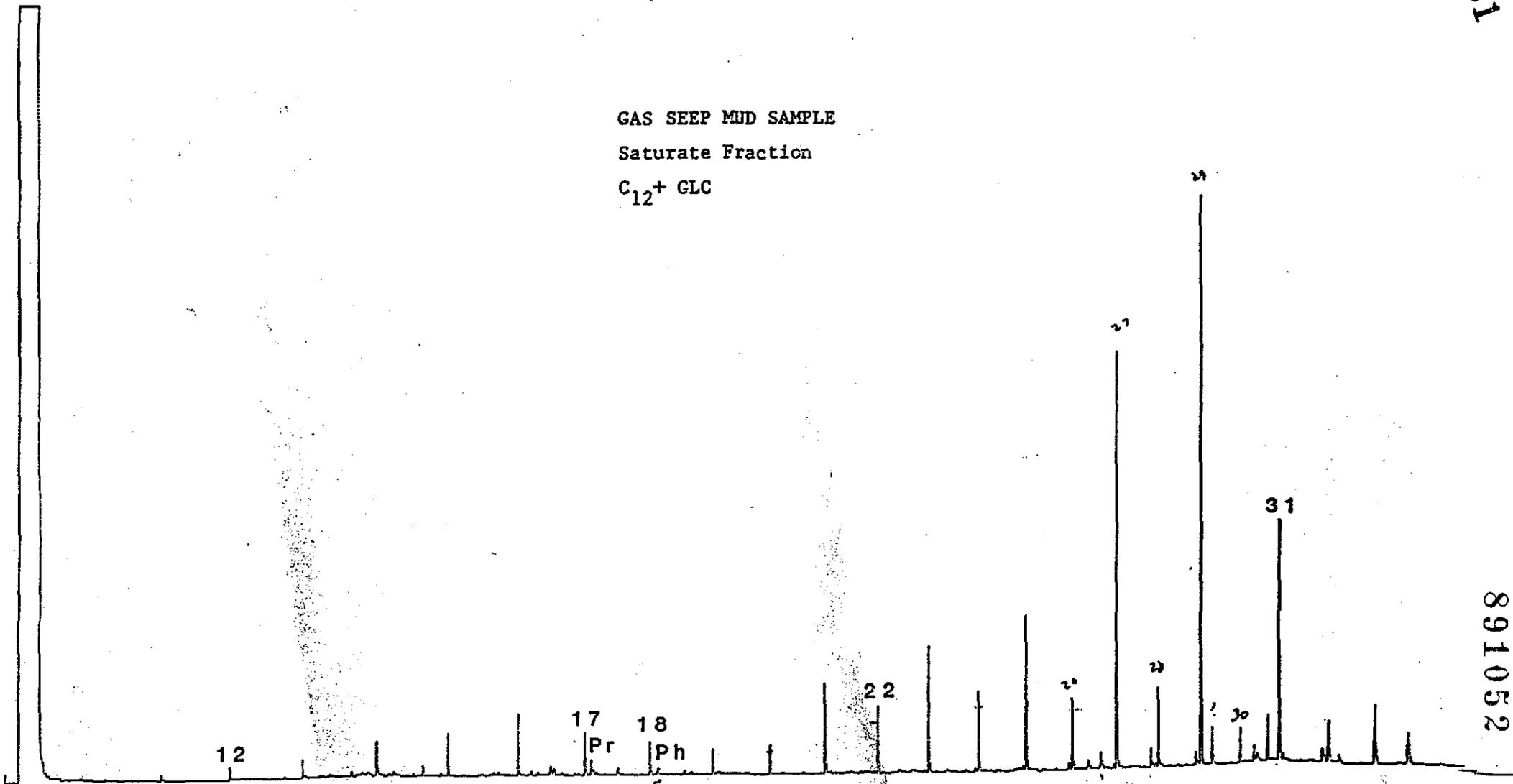
B. n-Alkane Distributions

Sample	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31
Gas Seep Mud Sample	.6	.8	1.7	1.9	2.8	1.9	1.1	1.6	.6	1.0	1.2	3.5	2.7	5.2	3.5	6.8	3.2	17.9	3.5	25.8	1.6	11.2

na = not applicable nd = no data

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GAS SEEP MUD SAMPLE
Saturate Fraction
C₁₂⁺ GLC



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TABLE

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: GAS SEEP MUD SAMPLE

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.79
2.	C ₃₀ hopane/C ₃₀ moretane	191	3.13
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	0.84
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	n.d.
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.69
6.	<u>C₂₉ $\alpha\beta\beta$ steranes</u> C ₂₉ $\alpha\alpha\alpha$ steranes + C ₂₉ $\alpha\beta\beta$ steranes	217	0.44
7.	C ₂₇ /C ₂₉ diasteranes	259	n.d.
8.	C ₂₇ /C ₂₉ steranes	217	n.d.
9.	18 α (H)-oleanane/C ₃₀ hopane	191	n.d.
10.	<u>C₂₉ diasteranes</u> C ₂₉ $\alpha\alpha\alpha$ steranes + C ₂₉ $\alpha\beta\beta$ steranes	217	n.d.
11.	<u>C₃₀ (hopane + moretane)</u> C ₂₉ (steranes + diasteranes)	191/217	3.60
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.36
13.	Rearranged drimanes/normal drimanes	123	0.88
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	2.57
15.	C ₁₅ alkyl cyclohexane/C ₁₆ homodrimane	83/123	17.10

n.d. = not detectable

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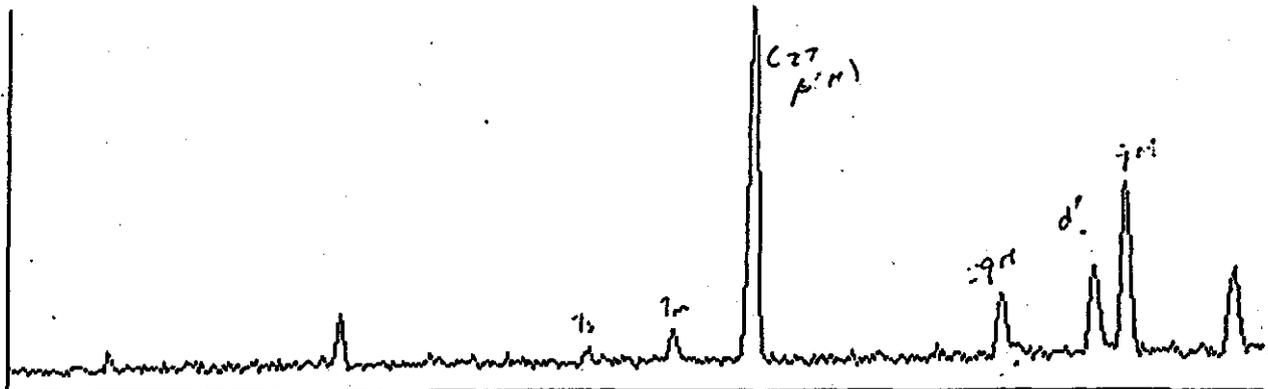
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CONGA OIL, TAS. MUD SAMPLE. BRANCHED CYCLIC FRAGMENTOGRAM.
24-11-86. GEC. 0.2/1501. COL*72.

FRN 6119

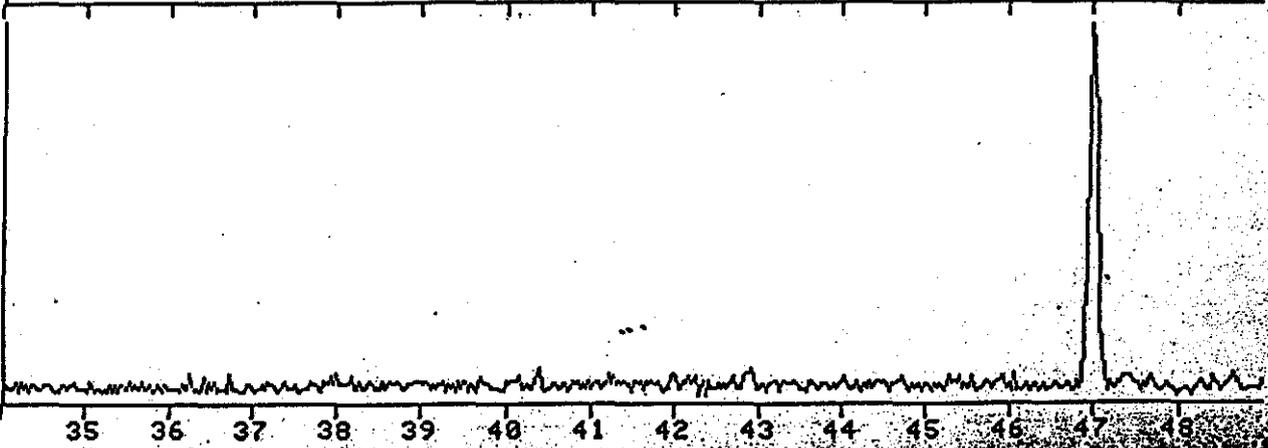
314

98.7
91.6



105

230.7
231.6

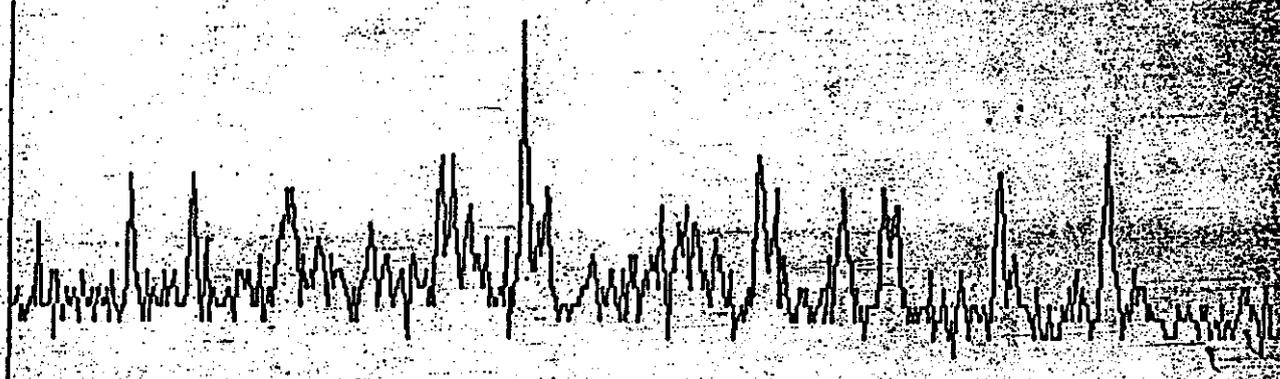


CONGA OIL, TAS. MUD SAMPLE. BRANCHED CYCLIC FRAGMENTOGRAM.
24-11-86. GEC. 0.2/1501. COL*72.

FRN 6119

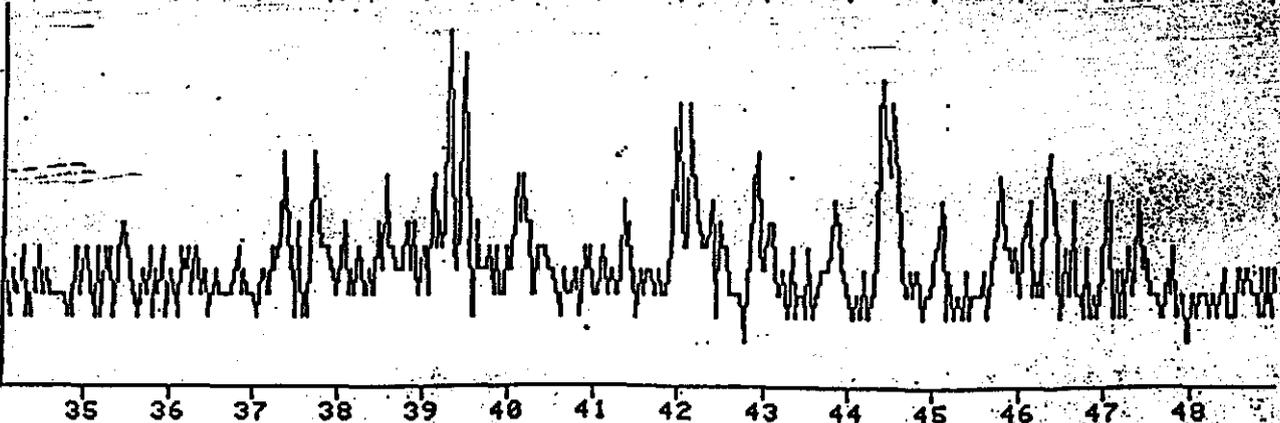
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16

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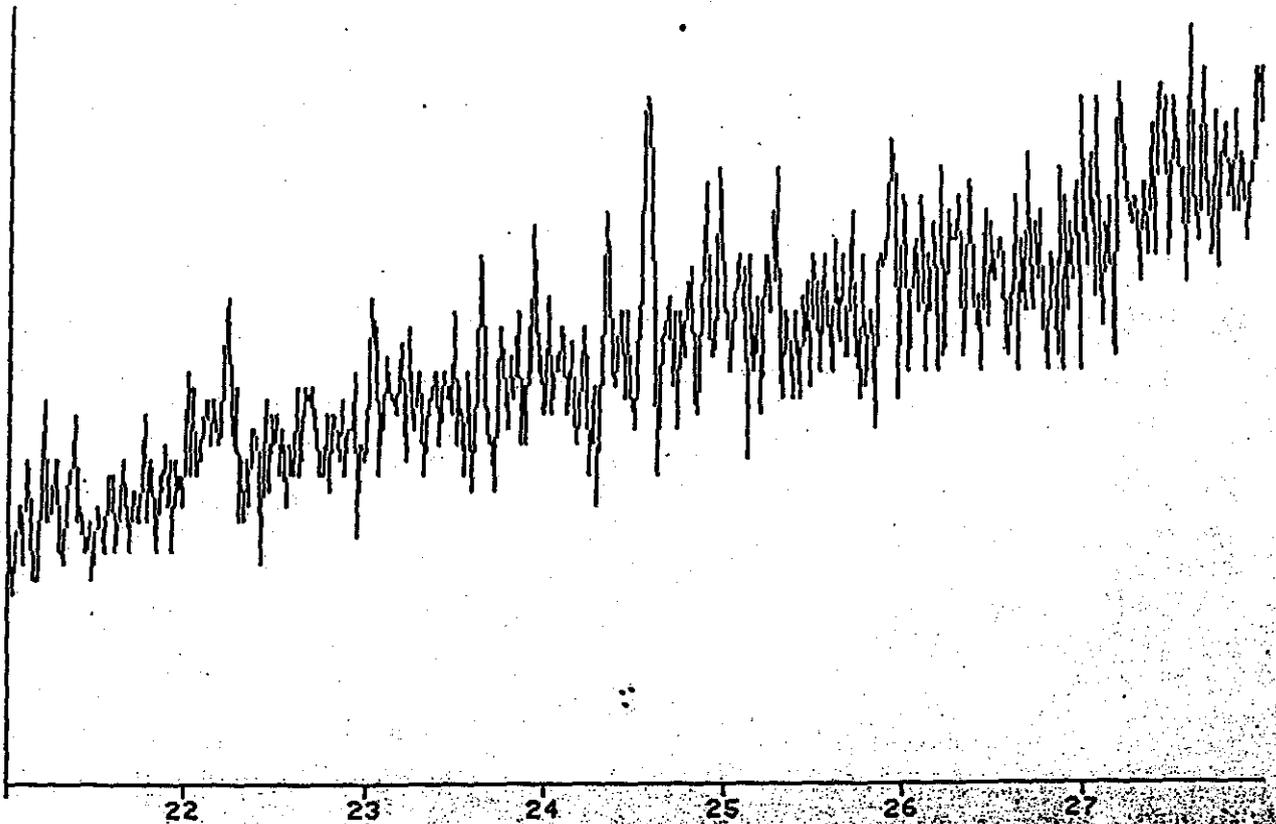
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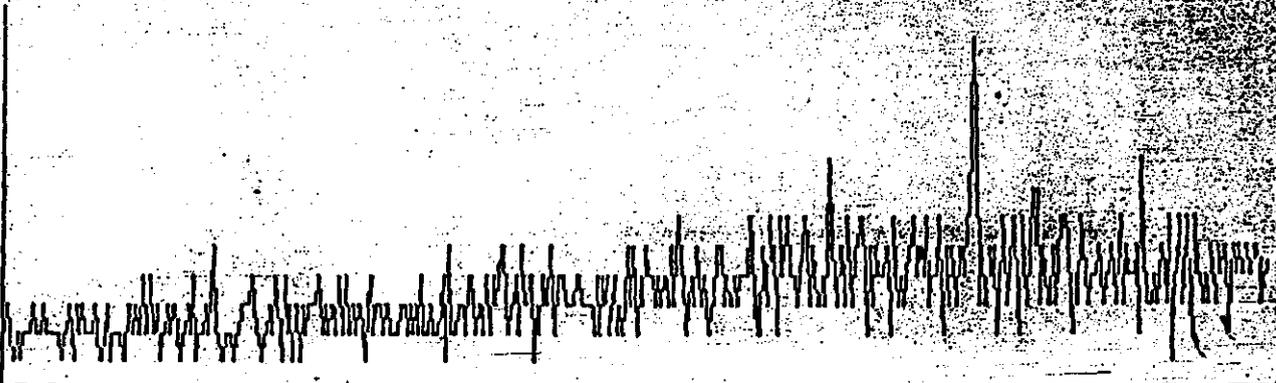


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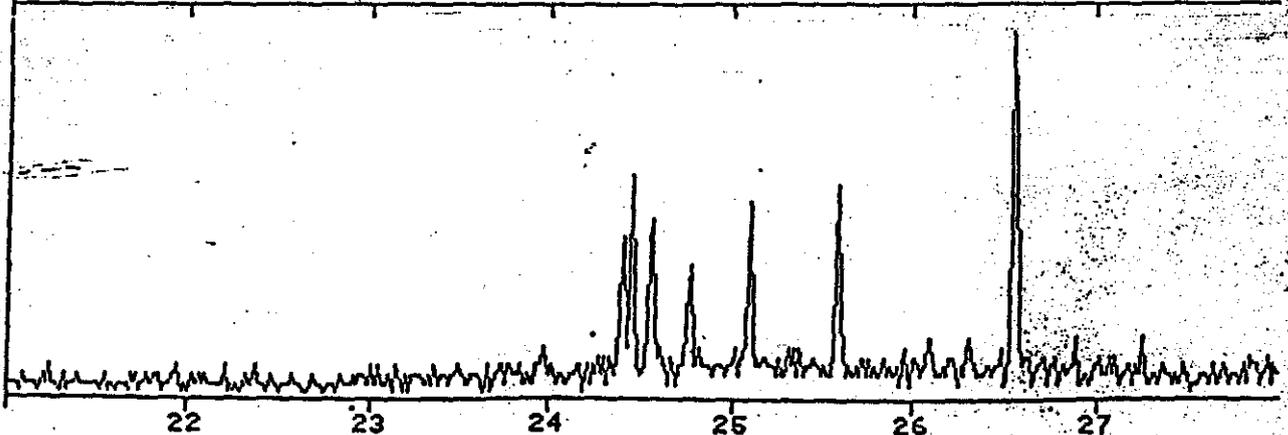
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259.6



42

273.7
274.6

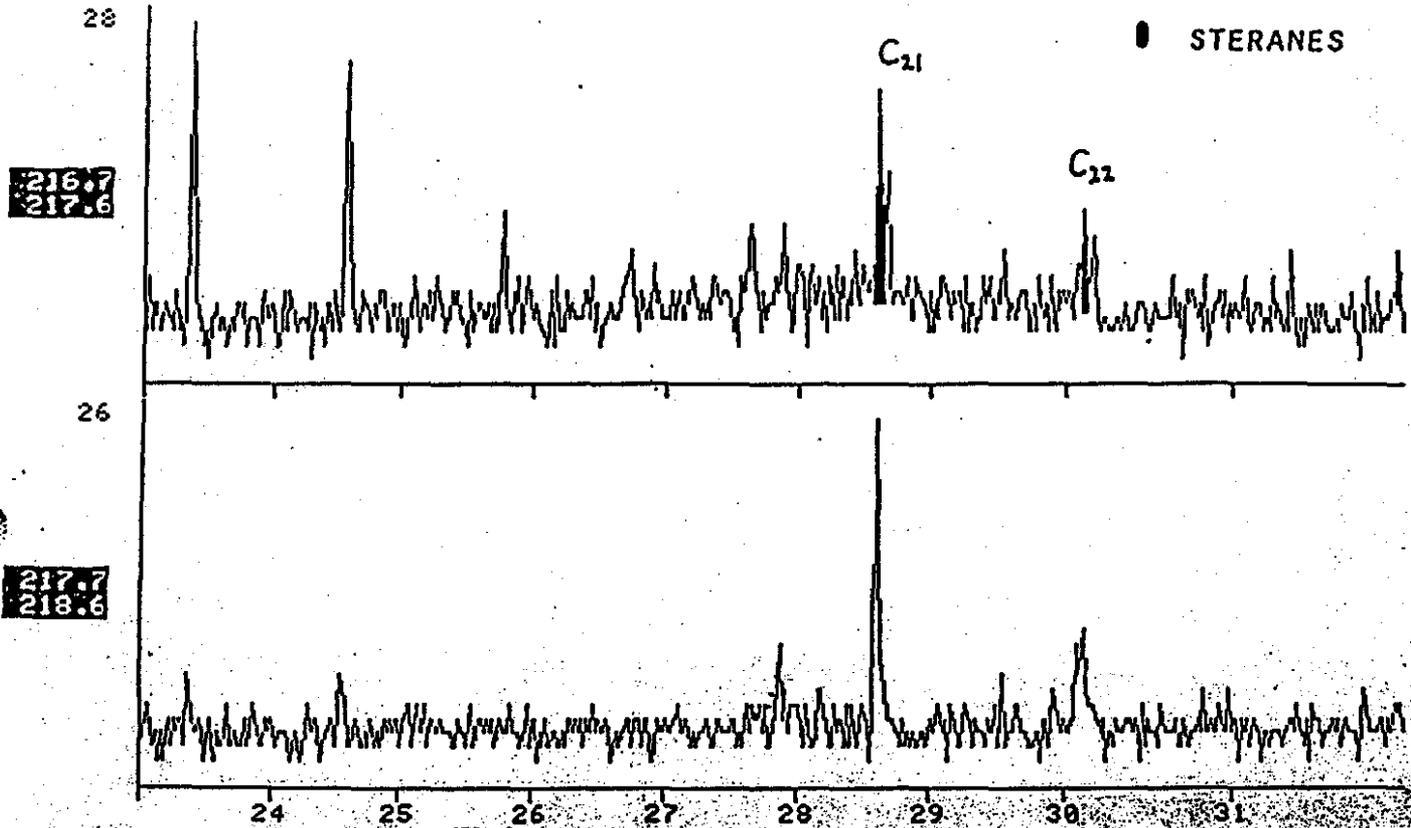


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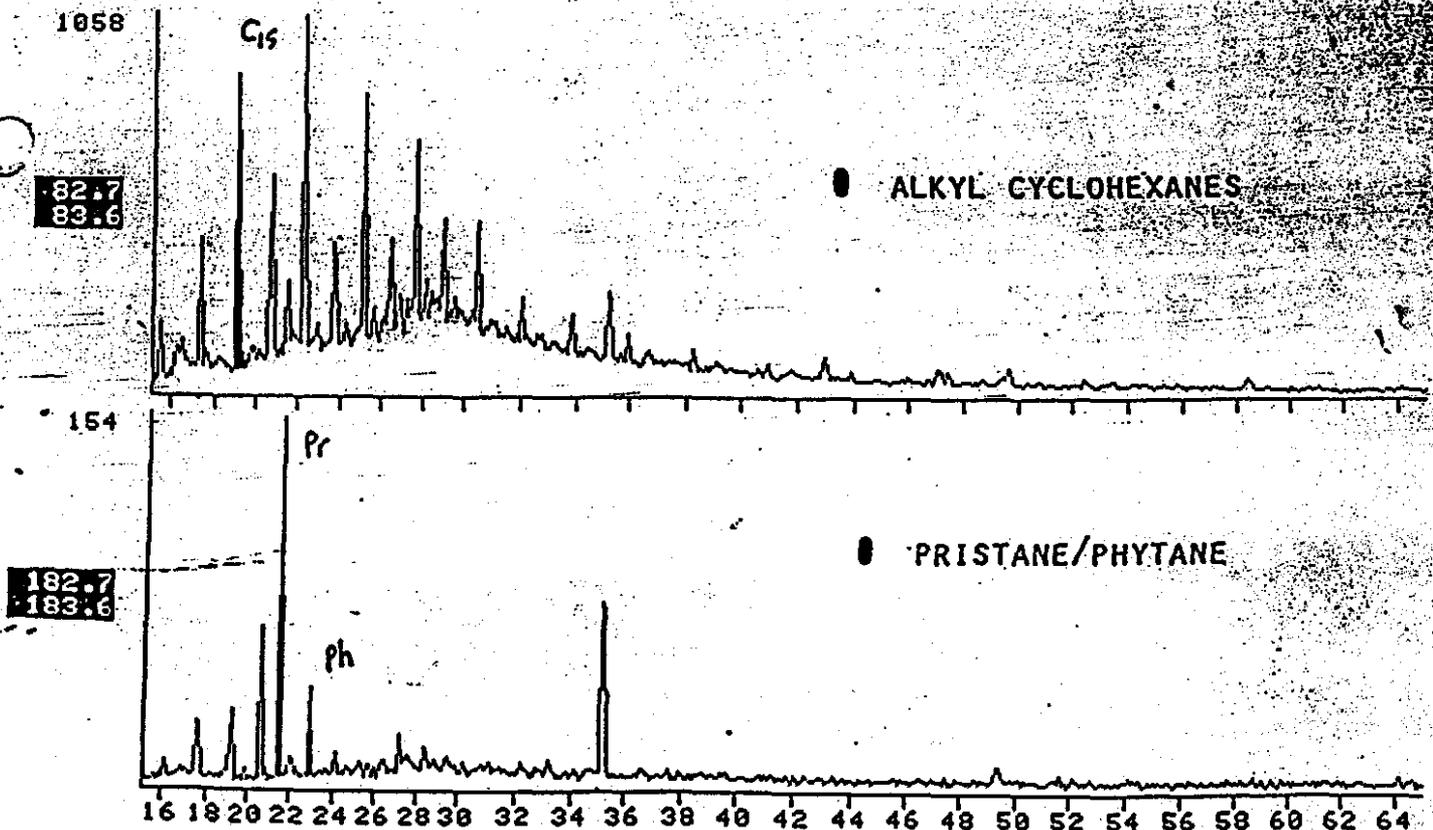
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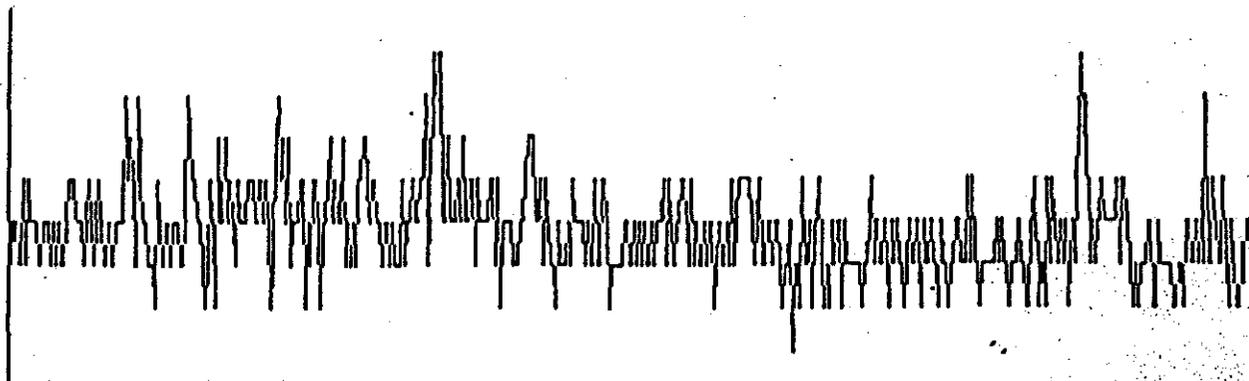
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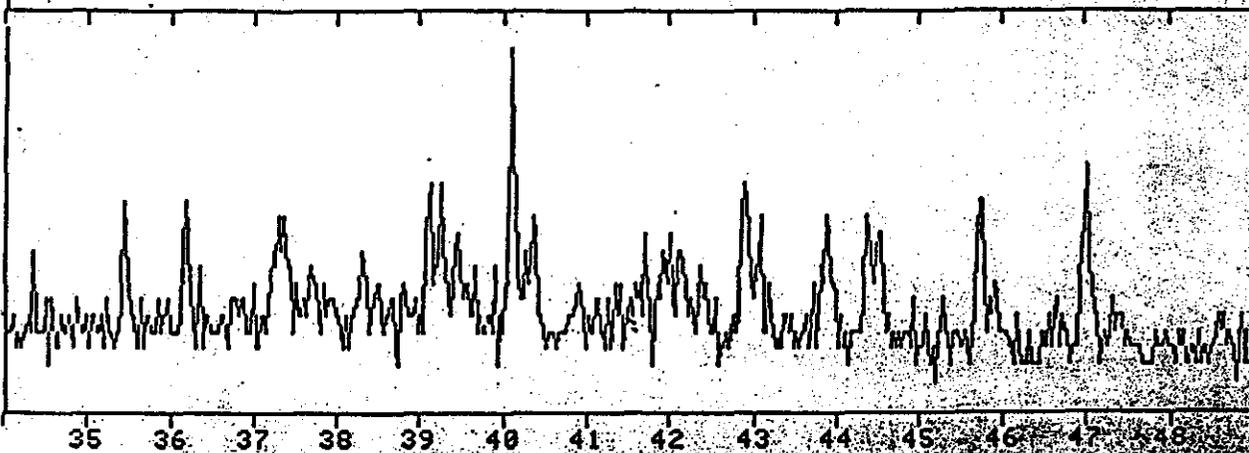
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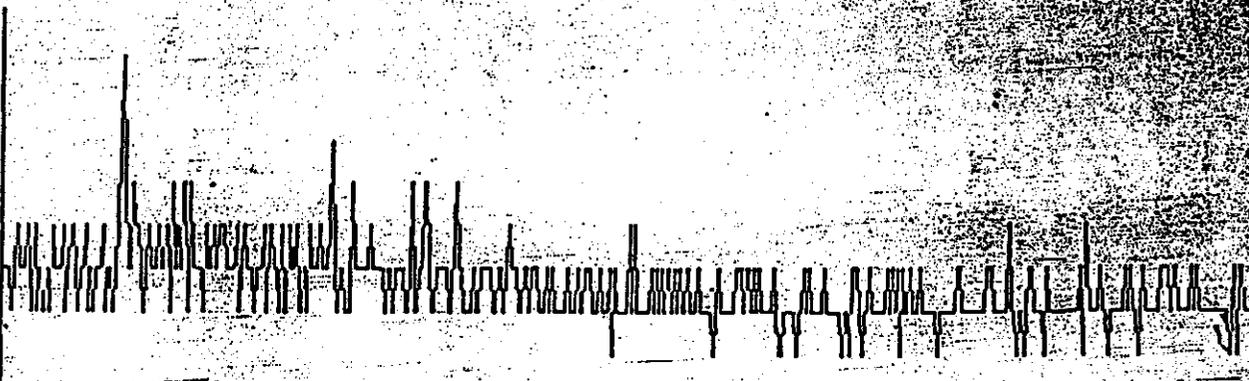


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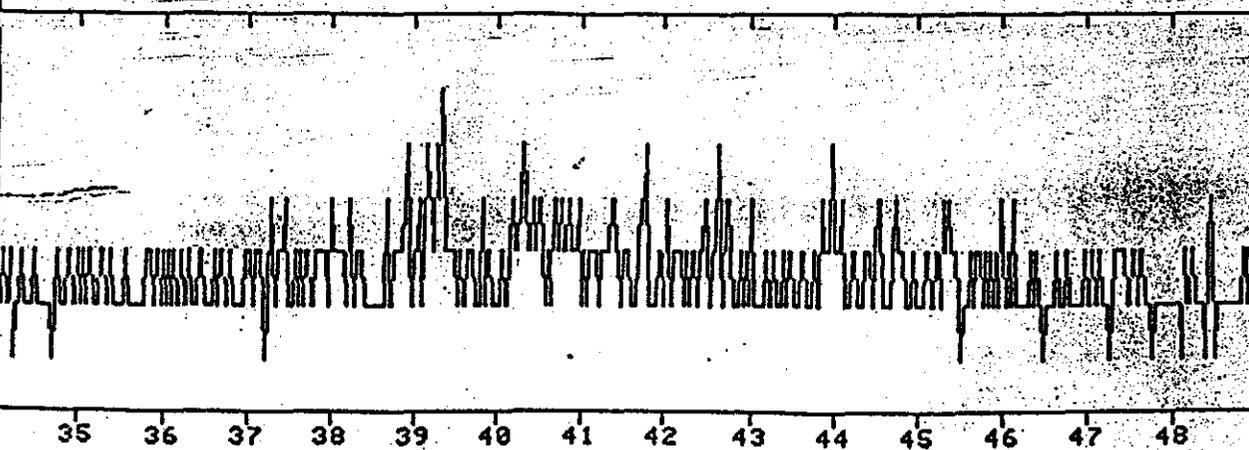
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372.6



7

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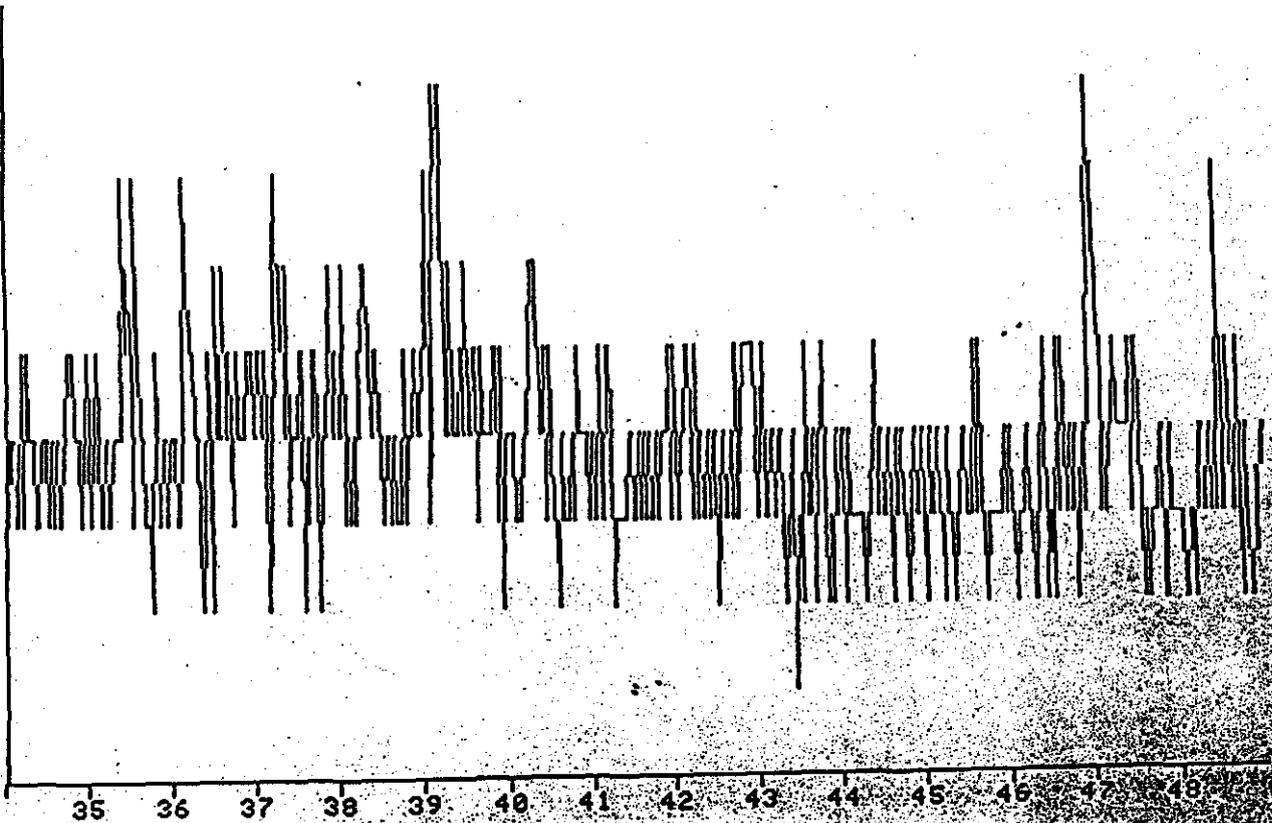


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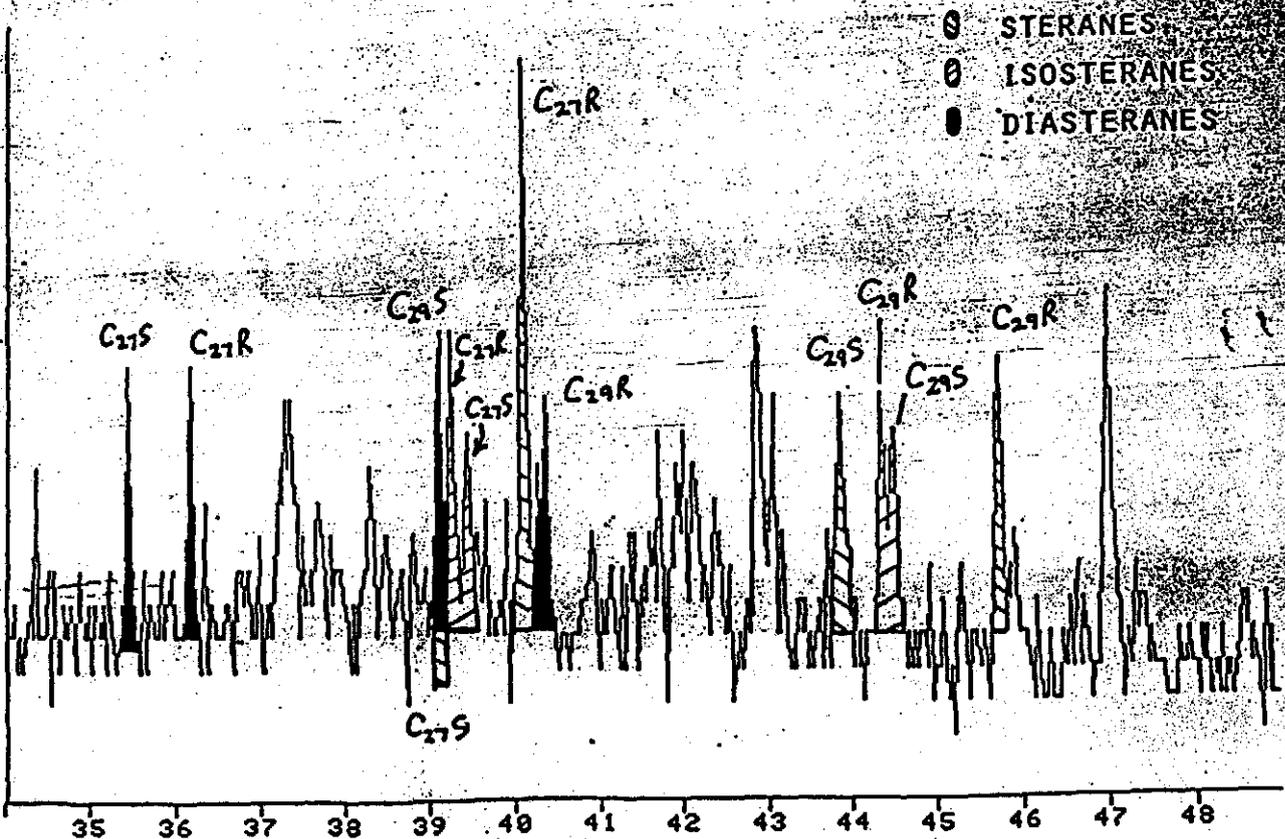
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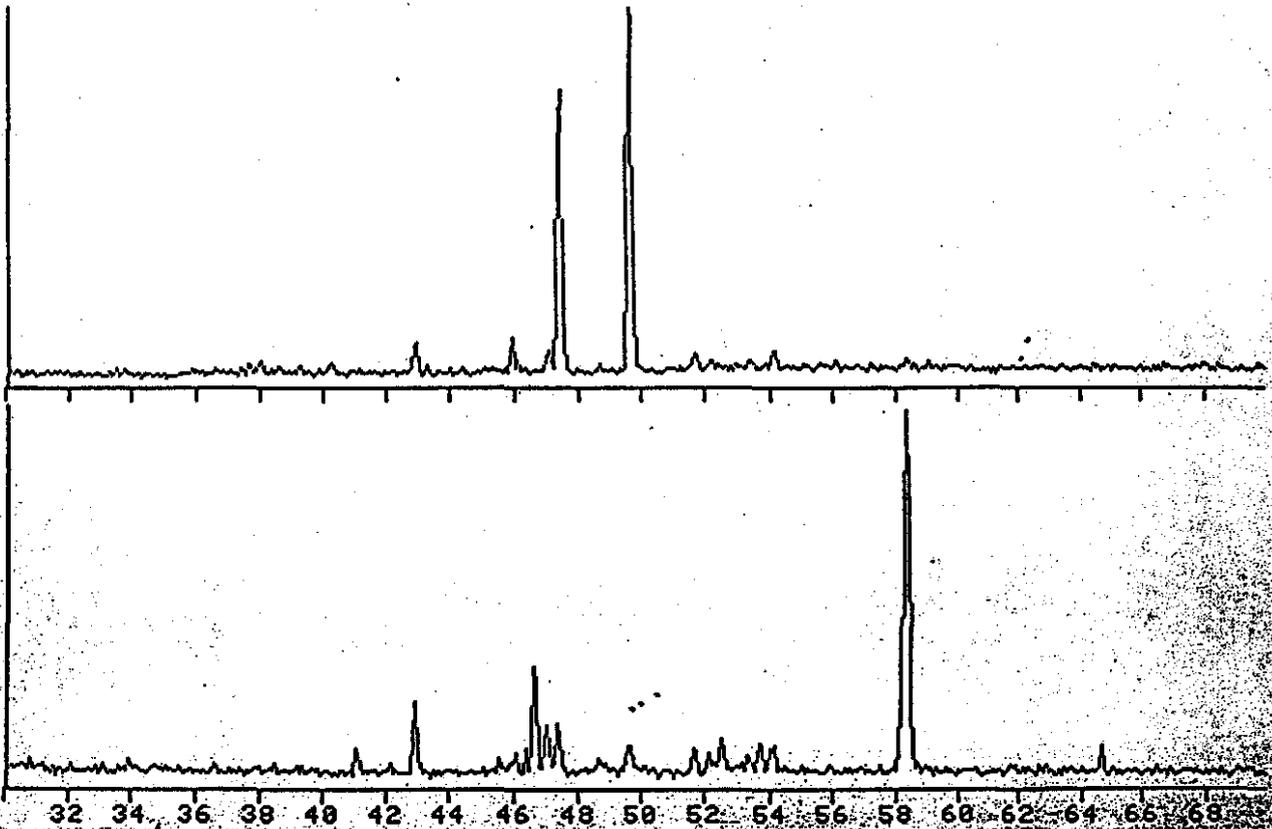
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318

176.7
177.6

135

204.7
205.6

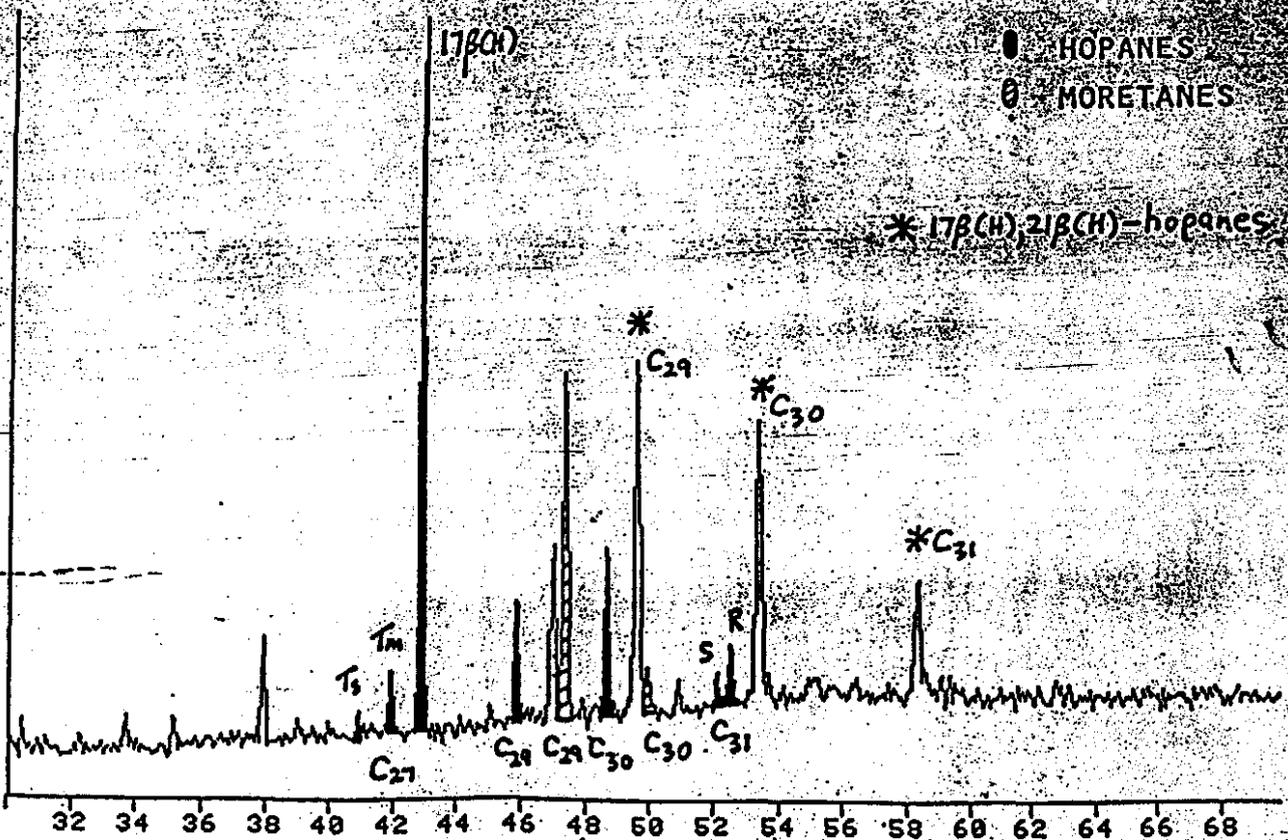


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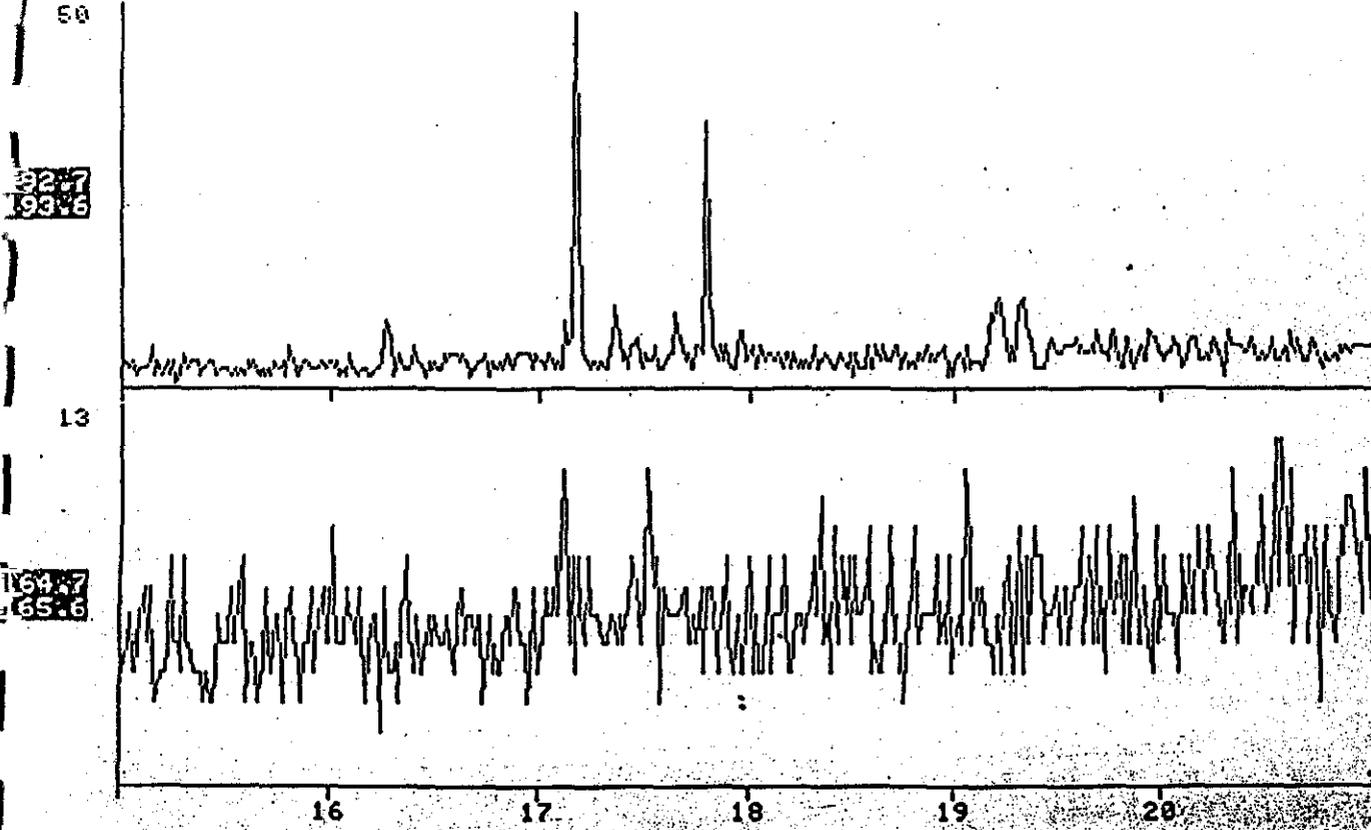


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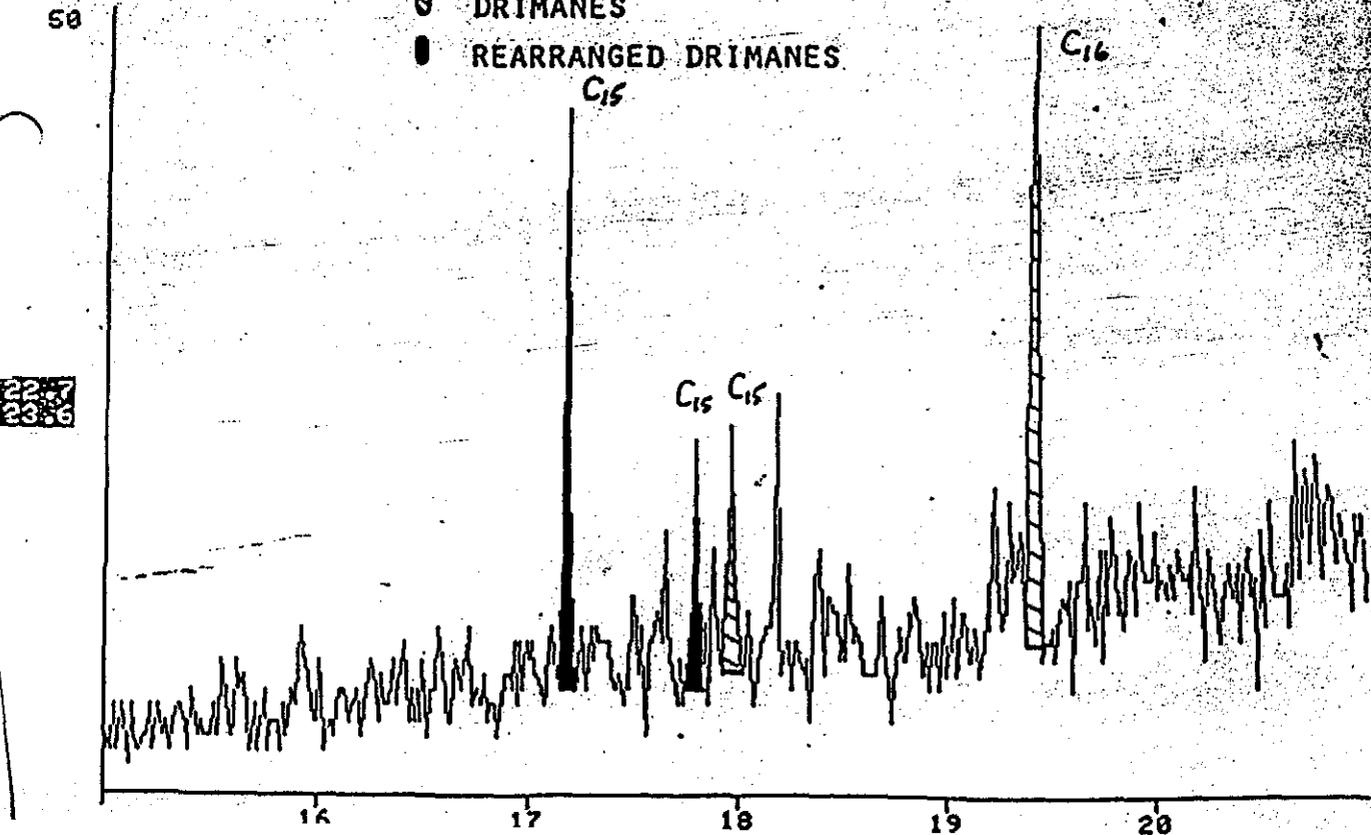
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○ DRIMANES
 ● REARRANGED DRIMANES



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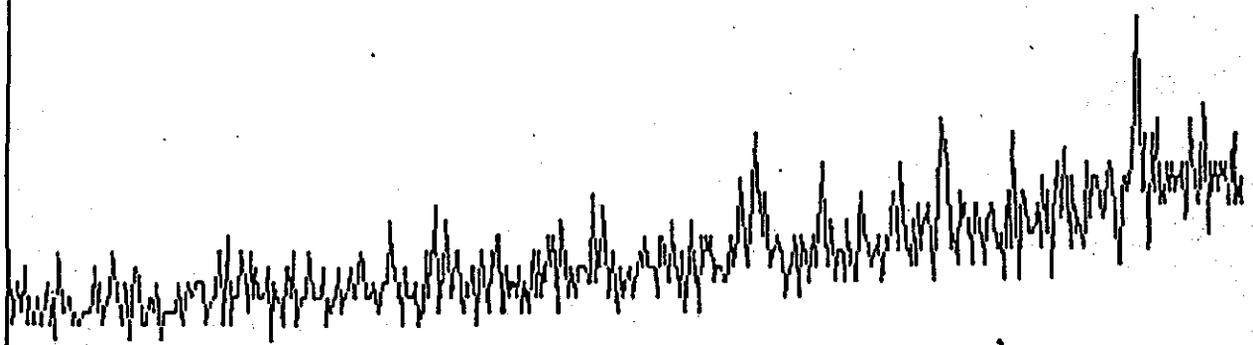
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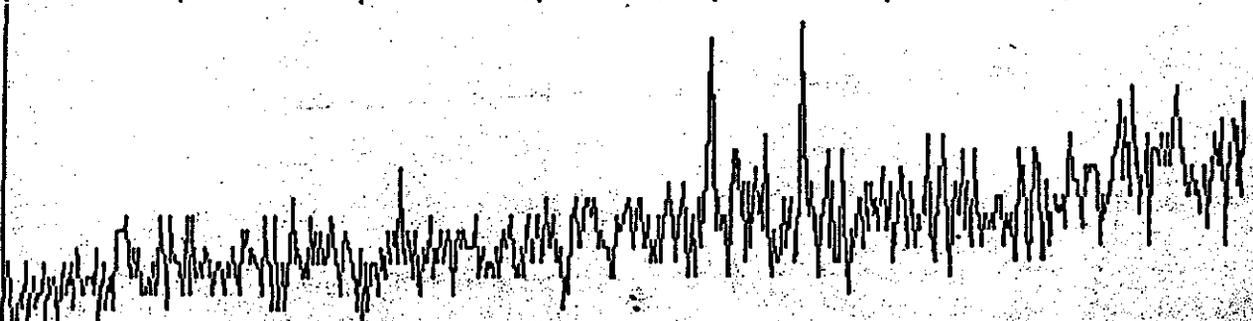
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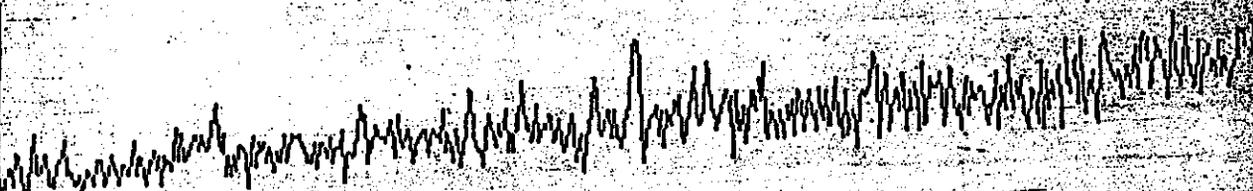
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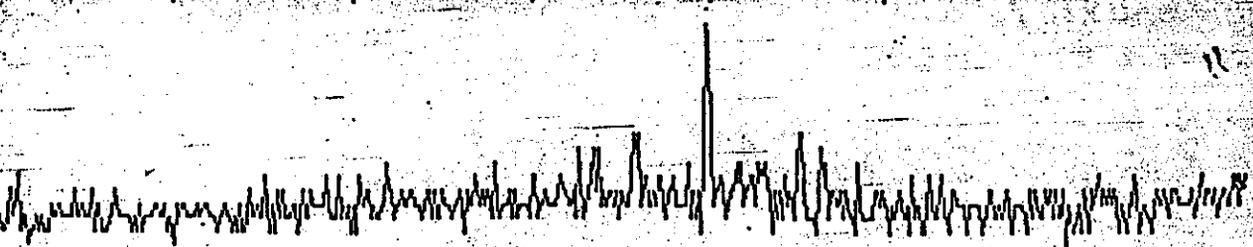
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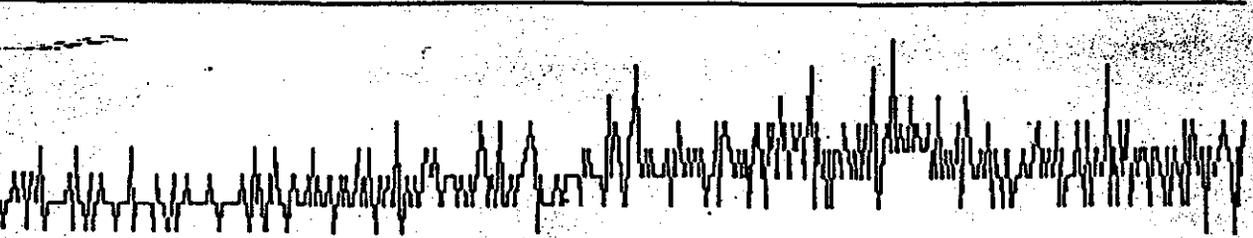
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Appendix 3

REVIEW
PRE 1987 GEOPHYSICAL AND STRUCTURAL DATA
D'ENTRECASTEAUX CHANNEL REGION
TASMANIA

by
Dr. D.E. Leaman

for
CONGA OIL PTY LTD

Feb 1987

Conga-3
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SUMMARY

A review of extant geophysical data in the D'Entrecasteaux region of Southeast Tasmania has found that available gravity, magnetic and seismic data is variable in quality and provides a very patchy coverage.

Geophysical data are essential to any regional or prospect evaluation or structural assessment in this region since probable source, reservoir and cap rocks are almost certainly deeply buried and wholly concealed, and effectively sealed, by a Permo-Triassic section intruded by Jurassic dolerite sheets which bears an unconformable relationship to the prospective materials.

There is negligible seismic data and that available affords little assistance to design of further surveys or structural appraisal. Other methods must be used to infer prospect sites, which may then be subject of seismic survey, since widespread onshore surveys could not be recommended for various technical and political reasons. Use of the waterways, while still posing some problems, would enable cross control of alternate methods and provide some definition on structural style.

It has been demonstrated that the cheaper gravity and magnetic methods can do much to provide the required structural skeleton. Limited interpretation has revealed a thick folded Cambrian section with fold amplitudes of at least 2 km. Folded wedges of Ordovician (source) and Silurian (poss reservoir) rocks overlie it. These data may also resolve Tertiary sediments and the forms of dolerite intrusions. No extensive interpretation is possible with present data, due to coverage limitations, and two gross pre-Permian concepts indicated cannot be resolved; thrust or plunging basement folds. A more even data coverage and whole geology 3D methods are required to determine which structural style is probable and then specify internal structuring. Enough data exists to show that this would be a feasible exploration approach. No simple interpretive techniques will have much application.

Some infilling of the extant gravity data base and a uniform aeromagnetic survey at about 1000 m elevation have been recommended as the most cost efficient initial approach. These surveys must extend beyond the areas of principal interest in order to allow structures to be traced through the licence areas and to avoid edge effects. The coverage must also provide sufficient detail within the licence areas to resolve major dolerite forms within the covering Permo-Triassic section.

INTRODUCTION

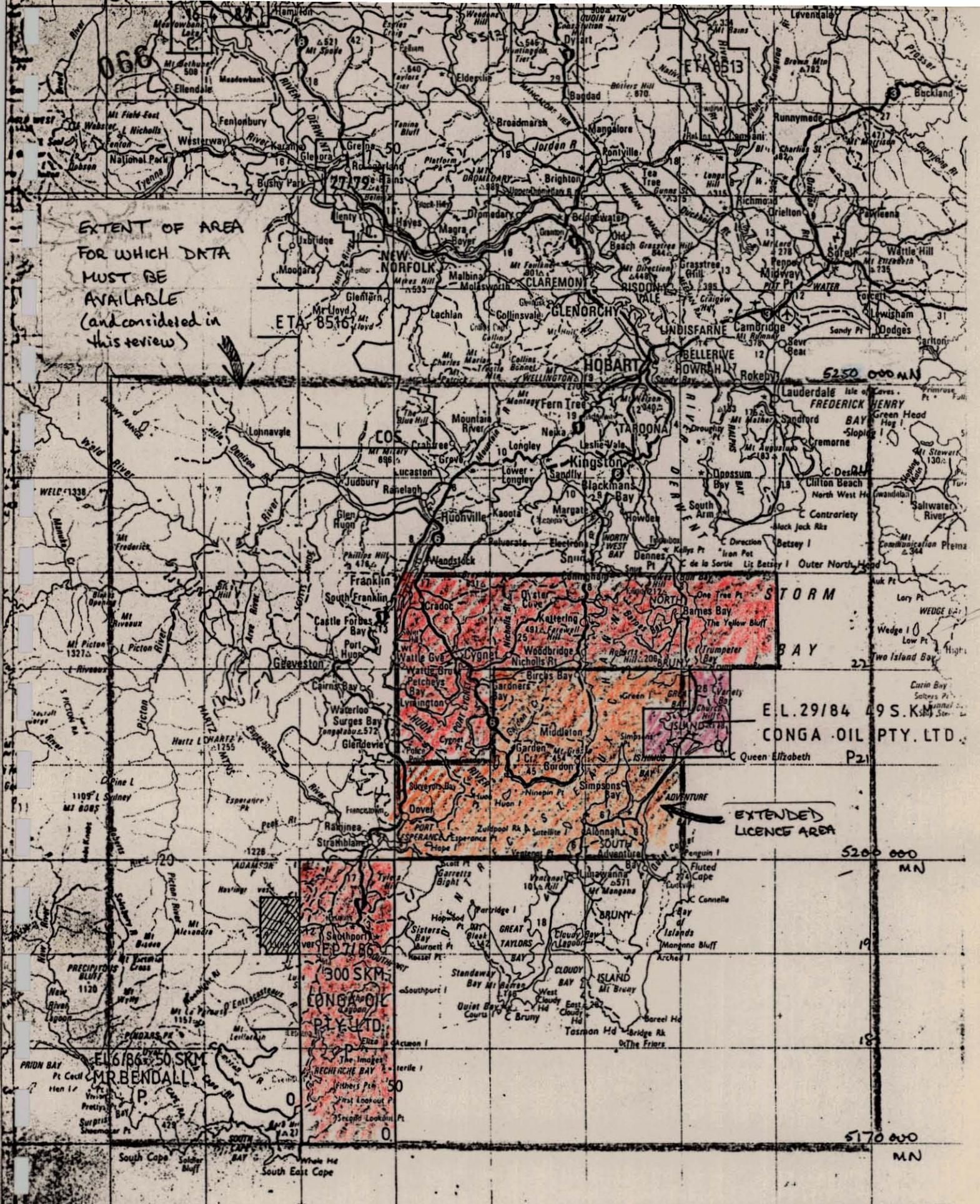
Following confirmation of a seepage of mineral oil on North Bruny Island, Conga Oil Pty Ltd has enlarged its exploration areas, from EL 29/84 on North Bruny and EL 7/86 south of Strathblane, to include the entire D'Entrecasteaux Channel-Huon River estuary region (see Figure 1). This expansion was essential to protect its interests and enable structural definition over a wide area. There is every possibility, given the unknown and almost certainly complex structural combinations present, that the oil may have migrated several kilometres laterally - or at least from beyond the confines of the original small tenements.

Present geochemical evidence suggests that the source rocks lie within the Ordovician Gordon Group. Reservoir rocks may include the source rocks or associated limestones, members of the Eldon Group (Silurian) and trap conditions could be related to Devonian folds, the Permian unconformity or dolerite intrusions. It is probable that generation was Cretaceous or post-Cretaceous in age but this is not critical since oil was generated, is still escaping and could be reservoirised or trapped in a range of features. Most of these features involve rocks older than Lower Permian in most instances and none of these are exposed anywhere in the exploration area. This fact poses a fundamental exploration problem; how to locate the interesting materials and define fine structures at minimal cost?

Since deep drilling by the Mines Department near Woodbridge has shown that the base of the Permian rocks lies at about 1000 m below sea level (M.J. Clarke, pers comm) - and are unlikely to be shallower elsewhere with the possible exception of Cygnet - it may be appreciated that reservoirs and traps are unlikely to be shallow and a broad structural appraisal is essential. No satisfactory well sites, realistic targets or target depths, or prognoses can be formulated without it.

Wild cat drilling of the seep area in EL 29/84 should not be considered until some feel for the concealed stratigraphy is in hand since success with it would force an appraisal in any case and failure, for undefinable reasons, would simply provide an expensive stratigraphic hole and not necessarily produce a general exploration benefit. Given the wide area of oil-affected material on North Bruny and the substantial fault relationships which may be tapping a variety of deep features including the Permian unconformity this would be a risky and dubious proposal at this stage.

This review constitutes the initial phase in exploration of the region and considers the value and implications of geophysical and structural data available to January 1987.



EXTENT OF AREA
FOR WHICH DATA
MUST BE
AVAILABLE
(and considered in
this review)

EXTENDED
LICENCE AREA

E.L.29/84 49S.K.M.
CONGA OIL PTY. LTD.

CONGA OIL
PTY. LTD.

EL 6186 50 SRM
MR. BENDALL

LOCATION PLAN

SOUTH EAST TASMANIA

891067

FIGURE 1

470 480 490 500 510 520 530 540 550
000 ME Sidmouth Rk

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GEOLOGICAL BACKGROUND

The following discussion is not a summary of Tasmanian geology. It is assumed that the reader will refer to other sources for more comprehensive descriptions of unit lithologies and relationships. My purpose in this chapter is simply to develop those issues which are pertinent to petroleum exploration in South-east Tasmania. Because little is as yet known directly of the geology, probable source and reservoir rock distribution, or structure beneath the Lower Permian units few absolute conclusions are possible.

Previous explorers have considered the hydrocarbon potential of the Parmeener Super Group rocks (Permian and Triassic), usually considered to occupy the Tasmania Basin, and relegated older rocks to "basement" and of no economic interest (e.g., Amoco, 1971). This partly reflects the existence of Lower Permian oil shales. None, however, are known south of Maydena or Bicheno. No explorer has acquired any data or interpretation relevant to structural definition within either the Lower Permian rocks or pre-Permian rocks, nor drilled deeply and the potential and distribution of older lithologies has remained undefined. Any potential has generally been dismissed.

Seepages have been reported over the years. Few have ever been sought by explorers since it has been assumed that the province must be barren. After all, "it is much disrupted—and where could the source rocks be? Any oil would be long gone!" This attitude has always reflected a view that the most probable sources lay in the Permian sequences and that generation would have occurred a long time ago. The location and chemical evaluation of the seep on North Bruny Island completely overturns this viewpoint. There are no known oil shale occurrences anywhere in the region and a true mineral oil is certainly escaping. Furthermore, it is probably reefal, and by inference, Ordovician in origin (below) — but not necessarily of Ordovician or even Palaeozoic generation. I have found this demonstration to be particularly interesting since I argued a case before CRA Exploration in 1982 that the Tasmania Basin did have oil potential — but at pre-Permian levels with an Ordovician source. In the absence of any indicators other than tars on limestone surfaces this possibility was dismissed.

Other seepages have been reported in the region (Cygnet and South Bruny) but none have been confirmed. Leaman and Naqvi (1967) were unable to definitely locate the Cygnet site but did not make an exhaustive search, nor analyse surface scums.

The non exposure of pre-Permian rocks within the Huon-Channel region could be considered to lead to uncertainty about the materials which might be present. There are, fortunately, few such doubts. The lithologies and sequences present must be essentially those of western and south-western Tasmania. There may be variations in thickness locally but comparable units and structural relationships must exist. The evidence may be summarised as follows. Upper Precambrian, Eo-Cambrian, Cambrian and Ordovician rocks are exposed beneath the Permian cover west of, or in, the Picton River and in the Hastings-Lune River region. These units may be readily correlated to the Maydena-Lake Gordon region, where Silurian rocks are preserved in the synclines, and to the type sections in western Tasmania. North east of Hastings and east of the Picton River there are no exposures but two deep boreholes have penetrated the Permian cover. At Woodbridge the thick basal tillite overlies phyllitic schist (Precambrian) while at Glenorchy (north of the review area) the tillite is virtually absent and the basement is Cambrian volcanics (Leaman, 1976). These holes confirm the extension of the lithologies up to 50 km east of the principal exposures.

An inspection of the geological map of Tasmania, however, will reveal the real problem. These units are folded and eroded and that structuring predates deposition of the Permian rocks. The fold blocks are patchily disposed and often relatively small (100 sq km) and may have a virtually random distribution when projected onto the Permian unconformity. The existing boreholes confirm this. The established North Bruny seep lies only 15 km east of Precambrian basement and yet its presence implies, somewhere nearby - if not beneath, folded Ordovician source rocks or post-Ordovician reservoir rocks. The key issue, therefore, is definition of occurrence and precise identification of potentially economic structures. Only then will the perspective offered by the seepages be understood. To appreciate the exploration potential and migration risk inherent in this area I have outlined the factors normally appraised for a basin opened for exploration. This area is special; hydrocarbons are present but the commercial significance remains to be established.

Few units are potential SOURCE rocks. Present evidence, in terms of field observations, conodont alteration and hydrocarbon chemistry all suggest that units within the Gordon Group have sourced the established seepage. No other sources can be conceived given knowledge of rocks in continental Tasmania and exclusion of the Permian oil shales. The age of GENERATION is uncertain. Hydrocarbons may, in the limit, be generating today. It is more likely, however, that generation was Cainozoic (Miocene) or late Cretaceous and that the confirmed seepage represents leakage directly from the source or reservoir unit. The reported presence of other seepages in the region may be significant. The area has a post Jurassic THERMAL HISTORY which is unique in southern Tasmania. Cretaceous igneous activity is restricted, as far as is known, to the Cairns Bay-Kettering-Gordon region (see Figures 1, 2)

but this distribution may simply reflect limits of exposure of the lowest Permian formations. Cretaceous intrusives are rare above correlates of the Bundella Mudstone even in those areas where "activity" appears to have been concentrated. This is an enigma related to these rocks. The actual bounds of the activity are not known. It is perhaps significant that the thermal springs at Hastings are marginal to this region.

Given that we may be dealing with an oil province, commercial viability depends on suitable reservoir, seal or closure conditions from the time of generation to the present day. This period is unlikely to be less than half the length of the Tertiary unless generation is continuing today. As will be shown it is unlikely that any oil generated prior to Jurassic disruption and intrusion could have been preserved. The twin issues of structure and reservoirs may now be considered.

Since the limestone members of the Gordon Group have been suggested as source rocks it must be noted that these may also act as RESERVOIRS. No older rocks can be considered reservoir candidates but some sandstone members of the Silurian Eldon Group might constitute excellent reservoirs. Other younger, pre Middle Devonian rocks may also be preserved which could conceivably serve this function. It is unlikely that any basal Permian units would provide good reservoir conditions; most are siltstones and mudstones with very fine matrices which depend on fracture systems for permeability. No unit above the level of the Bundella Mudstone can be considered due to regional dips and erratic exposure. Thus it may be concluded that any commercial reservoir, if present, lies within the Lower Palaeozoic rocks beneath the Permian unconformity (see sketch sections, Figure 3). Conceptual reservoir sites have been marked HC for hydrocarbon in these diagrams.

The style of a range of possible STRUCTURAL FEATURES can also be described with some certainty. An array of TRAP conditions is possible, many with limited closure. Some of these possibilities are suggested in Figure 3 but it is important to understand their origin in order to appraise methods for defining them.

All Palaeozoic units, including Permian units, may ONLAP Precambrian basement. Each may increase rapidly in thickness away from the point of onlap. Many units may be locally absent. Thus Permian rocks overlie Cambrian volcanics at Glenorchy and Precambrian schists at Woodbridge. Indeed the thickness of lowest Permian units may also vary considerably; there is virtually no tillite at Glenorchy but more than 600 m at Woodbridge and Cygnet. This demonstrates that the base Permian unconformity is an irregular surface and that the pre-Permian terrain had moderate relief. Younger Permian units are much more consistent in thickness and reflect basin development.

The base Permian UNCONFORMITY is an important, if irregular, surface. It marks the break between highly structured source and reservoir rocks and the younger SEALS. I

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am here presuming that the basal Permian rocks are relatively impermeable when compared with any likely reservoir and that the oil generation is, of course, at least post-Permian in age. It is possible that there are local concentrations of conglomerate at this surface which may act as reservoirs. The surface, though irregular, also has a regional dip of perhaps 5 or 10 degrees to the west. This dip dates from mid or early Tertiary epeirogenic events but does mean that the surface could locally transmit fluids upward to the east. The length of path possible depends on the development of relatively planar segments on the unconformity.

The principal potentially economic structures lie beneath the Permian rocks. Middle Devonian folding events have produced structures which tend to be longitudinal with a wavelength of little more than 2 km in many areas. These are relatively tight folds and may have local three dimensional closure. Due to the varied relationships with older basement plunging structures are common. It is therefore possible to conceive fold structures completely formed and preserved well below the unconformity. Many more structures are likely to be truncated by the unconformity since evidence elsewhere in the state demonstrates an array of associations were exposed at the time of commencement of late Carboniferous-Permian deposition. Plunging structures beneath the unconformity imply traps at the unconformity but possibly extensive migration paths. MIGRATION paths may be related to fold limbs, unconformity segments or post-generation faulting. Some older faults may also contribute to movement of fluids by interconnection with other structures. I have argued that it is unwise to drill on the confirmed seepage until some clearer conception of the local structure is available because of these complex possibilities. The faults which are leaking oil into the Permian rocks of North Bruny are at least Jurassic in age, were related to dolerite intrusion, but have been disturbed, probably very slightly, by Tertiary movements. This has allowed fluid rise. But where from? The source, the main reservoir or an intersection with another leakage path such as the unconformity? The dispersion of seepage implies either a very large reservoir or multiple surface intersection. After all, hydrocarbons could be weeping unreported into Storm Bay.

In addition, Jurassic faults must be reviewed with caution. Not all can be expected to penetrate deeper than the offsets required in the section to emplace the related intrusion. Such faults would not plumb great depths. It is possible that one third to one half of all Jurassic movements are of this type. Refer to Leaman and Naqvi (1967) or Leaman (1975) for discussions of intrusion related features. These comments should not be taken to imply that Jurassic disruption was insignificant. Major extension occurred with the formation of large horst and graben structures. This was followed by intrusion of thick dolerite sheets. These bodies, in excess of 300 m thick, have irregular forms and have transected each other to produce a complex stockwork. Up to three sheets may be expected in any given Parmeener Supergroup section and at least two of these are present in the Woodbridge and Cygnet

regions. One sheet, which has previously created difficulty for analysis - due to its unsuspected occurrence, lies near the Permian unconformity. This problem was discussed by Leaman (1976) in reviewing the implications of the Glenorchy bore hole and the dolerites in the Collinsvale structure. As the mechanism of intrusion depended on the layered heterogeneity of the Permian and Triassic rocks only these have been severely disrupted. The combined extension at all levels and the upper level disruption would not have allowed retention of any hydrocarbons developed to that time. It is also unlikely that burial conditions were generally suitable in any event. The effect of the development of the Permo-Triassic basin, subsequently intruded by dolerite, was to bury the unconformity at depths not less than 2 km in the Bruny Island region. Source rocks may have been translated commensurately deeper. The local Cretaceous thermal event has been mentioned above but the Jurassic event was larger and more widespread and could well have led to the onset of generation. The maintenance of a thermal regime would, however, have been critical to this process. An important consequence of dolerite intrusion was the filling of the extensional structures and re-sealing of the stratigraphic section. Dolerite intrusions possess only a fracture permeability and this is significant only at the margins of the bodies. The heart of any intrusion is virtually impermeable. Dolerite can thus form seal conditions which may be broken only by faulting or re-opening of older features. These are usually marginal to some shape change in the body and the seepages on North Bruny are probably related to minor disturbances of this type.

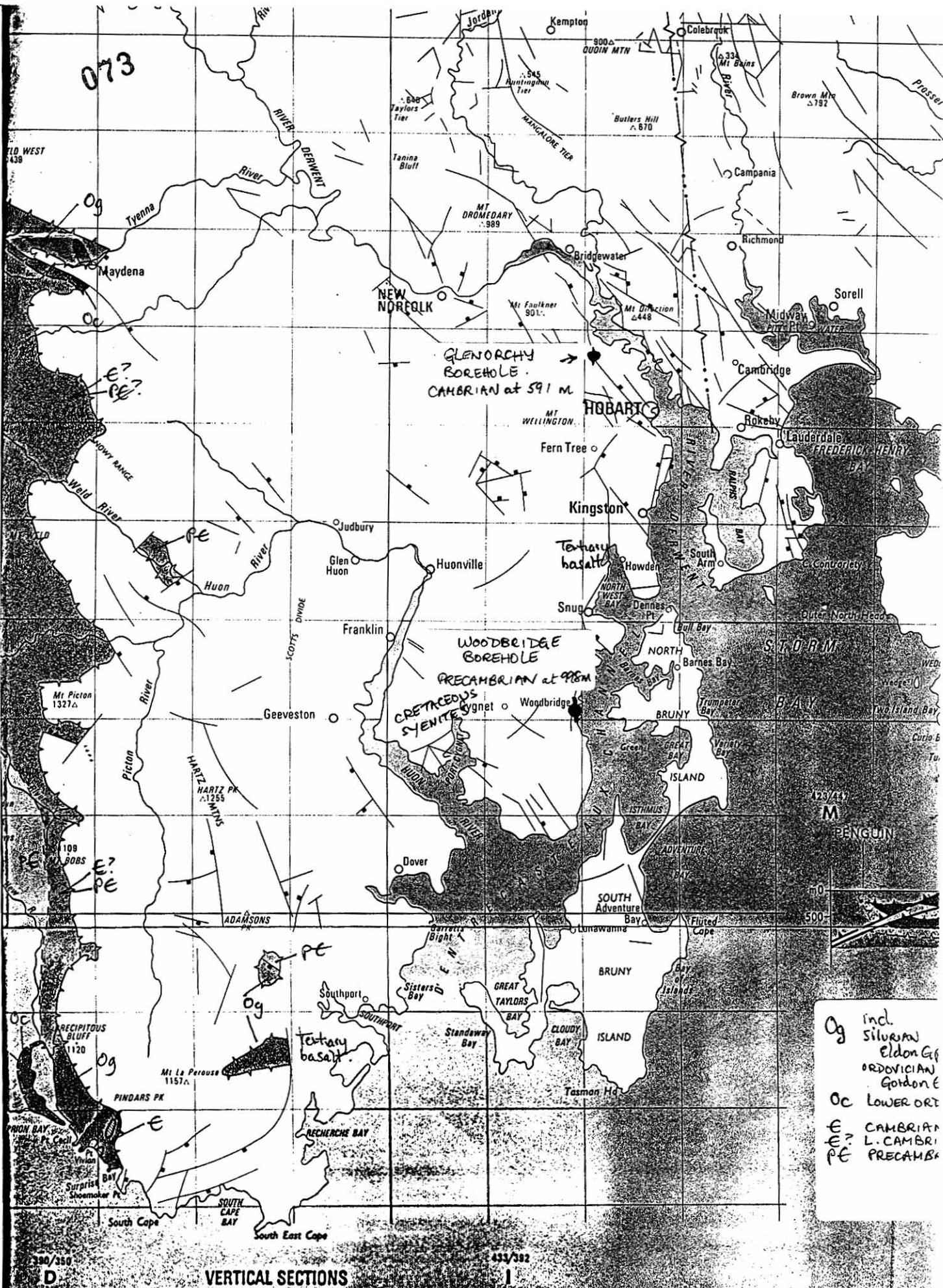
Post-Jurassic structuring is restricted in this region. There are few convincing Tertiary faults, no significant fault-controlled basins and limited volcanism. Tertiary volcanic rocks are restricted to the Lune River area or north of Snug. The principal fault zones are northeast of the coast from Blackmans Bay to Cape Queen Elizabeth; the line of this coast probably represents the western limit of the Derwent-Storm Bay half grabens. These exploration areas have been stable since the Jurassic with only minor disturbance in Cretaceous times. I therefore infer that any reservoir conditions developed by pre-Cretaceous or Cretaceous events will be preserved with fluids.

Tertiary sedimentation has occurred but appears to have been restricted to filling of drowned river valleys. These are known to exist within the Margate-North West Bay area and along the channel to the isthmus on Bruny Island. At least 300 m of sediment has been inferred in these channels. As indicated above the role of faulting has not been established.

In so far as oil exploration is concerned there are only two questions. Where are the source rocks and reservoirs? Do closure conditions exist? The exposed geology and the two penetrative bore holes available do little to answer these questions. It might be possible to study the pebble content of the basal Permian conglomerates and tills, as done by Leaman and Naqvi (1967) at Cygnet, in order to suggest the most

likely nearby source of pebbles. But this is a crude and uncertain approach probably confused by the stability of the various rock types and the possibility of long distance ice carriage. The pebble study did show, however, that even some unstable Silurian lithologies survived the transit and may persist locally. This is important since these are potential reservoirs. Surface trends, although dominated by Jurassic features, may also aid appraisal. Many probably represent rejuvenation of older structures and the unusual orientations of the Huon River and Channel coastlines may be significant. The only closure affecting post Permian rocks is at Cygnet where all rocks are domed. I argued, in Leaman and Naqvi (1967) that this feature was Jurassic in age. I no longer believe this. Dolerite intrusions do not lead to this style of structuring and the sheets also appear to be affected. It is more likely that the structure is related to the Cretaceous intrusions whose feeders were on a NE axis which almost bisects the bend in the Huon River. Since this bend may reflect deeper structure this pattern is consistent and doming is likely at the intersection of these axes.

Geophysical data offer the only economical means of inferring rock distribution and gross structure on a regional or prospect scale in the prevailing circumstances. But the problems are neither trivial nor readily resolved due to lack of control and the blanketing effect of the massive dolerite intrusions.



073

GLENORCHY BOREHOLE
CAMBRIAN at 591 M

WOODBRIDGE BOREHOLE
PRECAMBRIAN at 995 M

Og incl. Silurian
Eldon Gp
ORDOVICIAN
Gordon
Oc LOWER ORT
E CAMBRIAN
E? L. CAMBRIAN
PE PRECAMBRIAN

D

VERTICAL SECTIONS

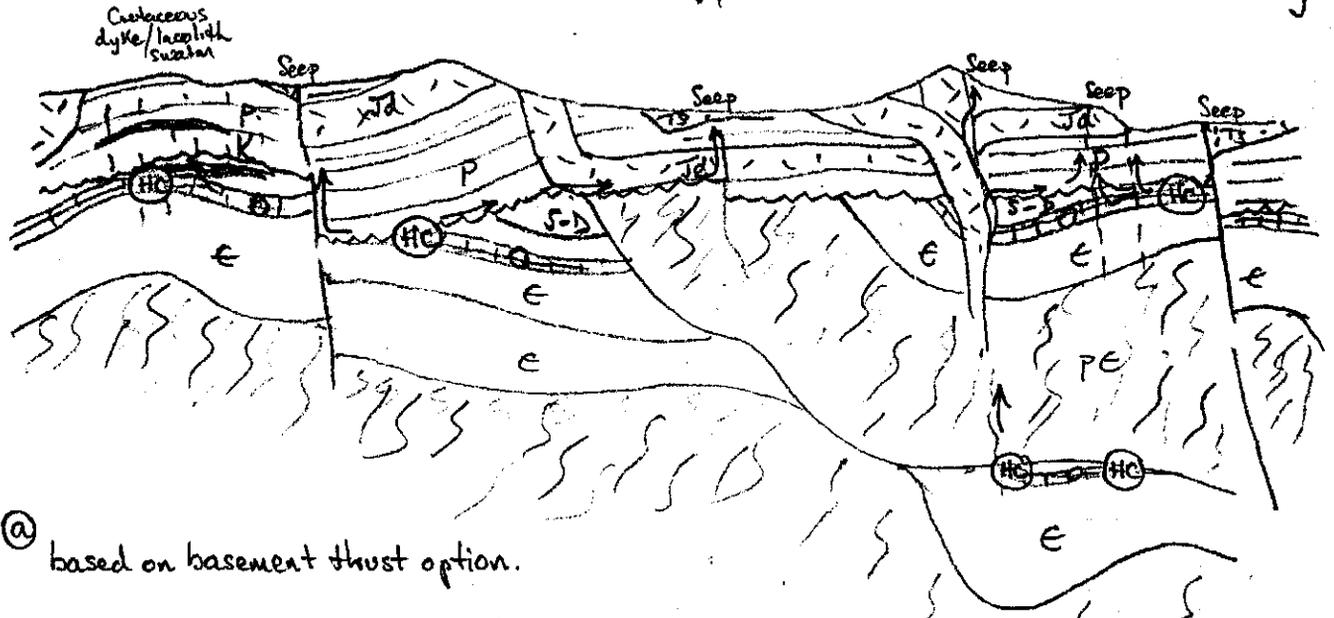
I

891074

DISTRIBUTION OF PRE-PERMIAN AND CRETACEOUS ROCKS

FIGURE 2

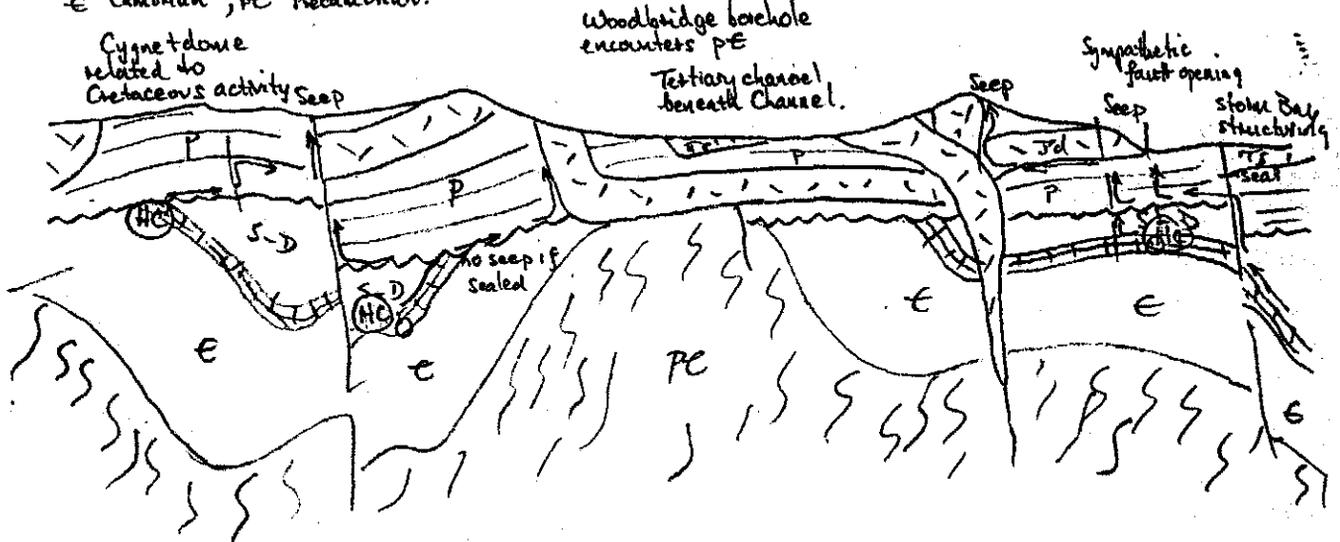
(after structural map - Geol Surv. Tasman.)



(a) based on basement thrust option.

Note ways in which Permian unconformity might be used in migration paths. Bruy seeps may be related to sympathetic opening of old fractures parallel to Storm Bay movements. No great displacement implied. Note also that some reservoirs/structures could exist and not leak due to various types of seal and no later fracturing.

T_s Tertiary sediment; C Cretaceous; J_d Jurassic dolerite; P Permian; S-D Siluro-Devonian; O Ordovician; C Cambrian; PE Precambrian.



(b) based on plunging basement anticline option.

South of Woodbridge the anticline could contain other Palaeozoic rocks and if crenulated could contain traps in its own right. Alternatively its intersection, with source or reservoirs, with the Permian unconformity could lead to very dispersed migration paths.

WARNING: Diagrams not to scale and not intended to portray probable structures at any level. These will not be known until exploration and interpretation is much more advanced. Diagrams only suggest how seeps might arise.

DIAGRAMMATIC PRESENTATION OF ROCK RELATIONSHIPS

FIGURE 3

GEOPHYSICS

INTRODUCTION

Available geophysical data have been collated and inspected. Information is relatively sparse and of variable quality but has been reviewed with three principal objectives.

1. To assess likely usefulness of existing data or extensions of surveys or particular methods to the problems outlined in the previous section.
2. To consider what might constitute appropriate specifications for any new surveys required.
3. To attempt a demonstration extraction of regional structure using the present data in order to evaluate criteria for 1 and 2 above as well as to indicate the methods which must be applied to an updated data base. It was hoped that sufficient data existed to provide an initial skeleton interpretation.

MAGNETICS DATA

Data from five magnetic surveys are relevant to the exploration of the D'Entrecasteaux Channel region. These are

1. BHP South West Tasmania aeromagnetic survey (BHP, 1966). Flown at 150 m mean terrain clearance with a 400 m line spacing and contoured with 10 nT interval. Figure 5 reproduces the entire survey while Figure 6 provides a sample from the Hythe area. No original observations are available for this survey and it is not known how well the mean clearance specification was kept or what assumptions are implicit in the contour map. No profiles exist. This data is of little direct benefit to exploration of the greater Channel area since only the fragment reproduced in Figure 6 lies within the study area.
2. BMR high level survey of Tasmania (Finney and Shelley, 1967). Flown at an elevation of 3000 m with a nominal line spacing of 15 to 20 km and contoured at 50 nT intervals. Figure 7 shows contours of part of this survey coupled with a compilation of other coastal surveys (all at much lower levels). E-W position errors of 3 km are possible and some smoothing of profiles (Figure 8) is likely but undefined. This survey provides the only overall magnetic coverage of the region but its value is restricted by the very wide

line spacing and smoothed presentation. It still has much to offer as shown in a subsequent section.

3. ESSO/EZ Storm Bay aeromagnetic surveys. (Esso, 1965)
Flown at 500 or 1200 m (not clear which parts) with a line spacing of about 3 km. The relevant parts of these surveys are presented in Figures 9 and 10. Bruny Island is covered. No original observations are available for this survey and the curious contouring rules cannot be confirmed; nor can height information or profiles. These deficiencies do limit the usefulness of the data (see survey comparisons below). The data is sufficient to permit a rough interpretation of the Storm Bay region.
4. North Channel marine seismic survey (Francombe, 1978).
Various traverses of no particular orientation, contoured at 100 nT interval. Coverage patchy but able to suggest Tertiary channelling. See Figure 11.
5. MARATHON Catamaran-Strathblane aeromagnetic survey (Rutter 1983).
Flown at 90 m mean terrain clearance, with 500 m line spacing and 10 nT contour presentation. A sample of this survey which covers part of EL 7/86 is shown in Figure 12. This data provides an example of survey overkill. Flown with a very high resolution magnetometer and at levels quite unsuitable in Eastern Tasmania. Due to the amount of exposed dolerite the results are complex and not easy to interpret, either in terms of deep structure or the dolerite intrusions themselves. See discussion below. Profiles are available for this data and one is reproduced in Figure 14.

The coverage offered by these surveys is summarised in Figure 4. Magnetic data can normally be used to provide a structural skeleton for a study area but it must cover it all and be treated appropriately. Initial inspection of the Storm Bay, South West and Marathon surveys picks out the dolerite areas but does not immediately suggest anything about deeper units or structure. In contrast, the high level BMR survey is almost wholly dominated by gross pre-Permian structures and dolerite effects contribute little. This filtering effect occurs as a result of change in flight elevation; high frequency anomalies due to near surface sources are minimised with increasing elevation. This effect can be seen at much lower levels. Figures 6 and 12 cover essentially the same areas although there is a scale change. It is possible to recognise and compare features and confirm reproducibility but this is neither simple nor obvious. The differences are related more to the nominal 60 m in elevation than to improvements in instrumentation in the period between the surveys.

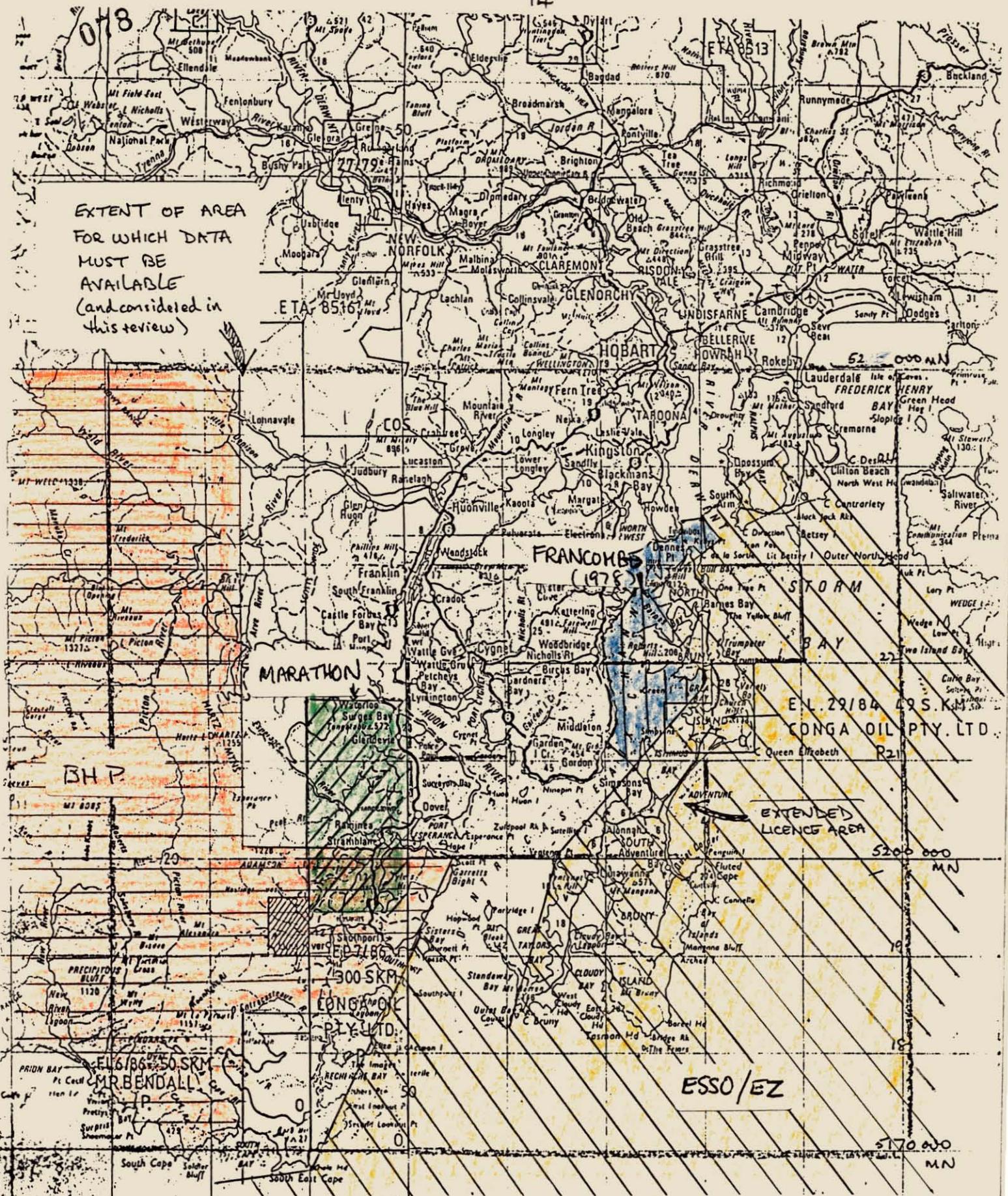
Figures 13 and 14 enable some assessment of the reliability and reproducibility of the various surveys. Figure 13 compares the overlap between the high level BMR survey and the EZ survey across the northern part of Storm Bay. The

Figure shows that all salient features are reproduced although there is an apparent scale problem at the western end of the profile. The calculation upward to comparable elevations presumed that the reported elevations were accurate. This is clearly not generally true. Nor did the calculation allow for the anomalies off line at the western end. This reflects line end conditions and the interpolations made from the contour map in order to make the comparison. The surveys are crudely reproducible at a level of 3000 m but clearly great care would be required in using them at lower levels for any quantitative study.

Figure 14 presents a comparison of anomalies to be observed at various elevations based on line 2251 of the Marathon survey. The first profile shows what was observed while the second and third show what would have been observed had the survey taken place at elevations of 600 and 3000 m. From a regional study viewpoint little useful information has been lost at 600 m and from a grossly regional outlook the 3000 m profile, which is consistent with the observed BMR profile at this northing (5200 000 mN), is still useful. At elevations of less than 1000 m structures within 500 to 1000 m of the surface can still be resolved in some detail; above that elevation only structures below 1000 m, or which are large areally, can be resolved.

The marine data of Francombe (1978) is not directly comparable to any of the airborne data either in quality, reproducibility or coverage. Its principal value at the present time is to suggest shallow limits of dolerite intrusions beneath the waters of the channel.

EXTENT OF AREA FOR WHICH DATA MUST BE AVAILABLE (and considered in this review)



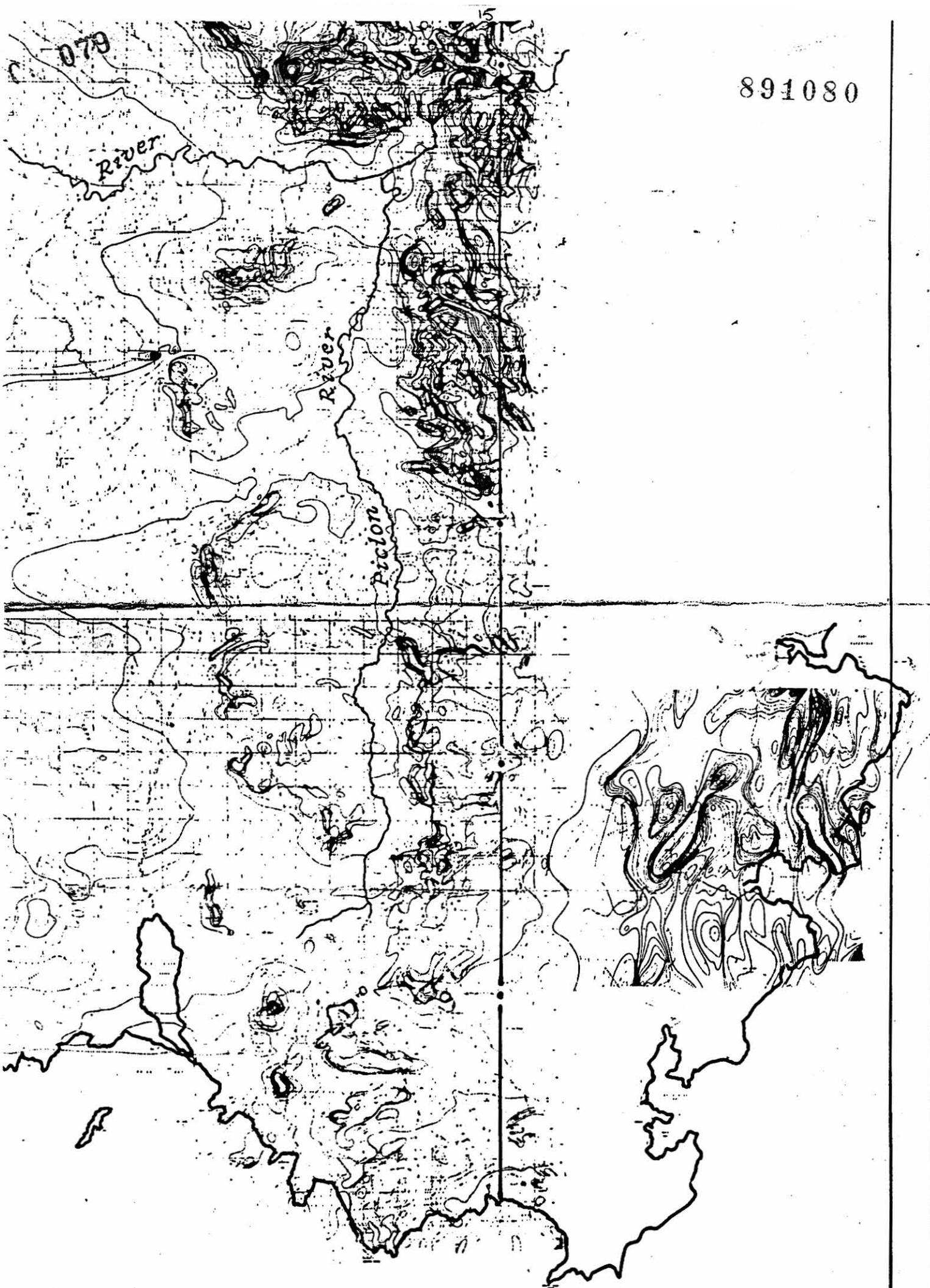
COVERAGE OF MAGNETIC SURVEYS

- ==== BHP SW Tas
- ==== BMR high level survey
- //// ESSO/EZ
- |||| Francombe (1978)
- //// Marathon

891079

FIGURE 4

891080



BHP SOUTH WEST TASMANIA AEROMAGNETIC SURVEY - OVERVIEW

FIGURE 5

080

D. E N T R E C A S

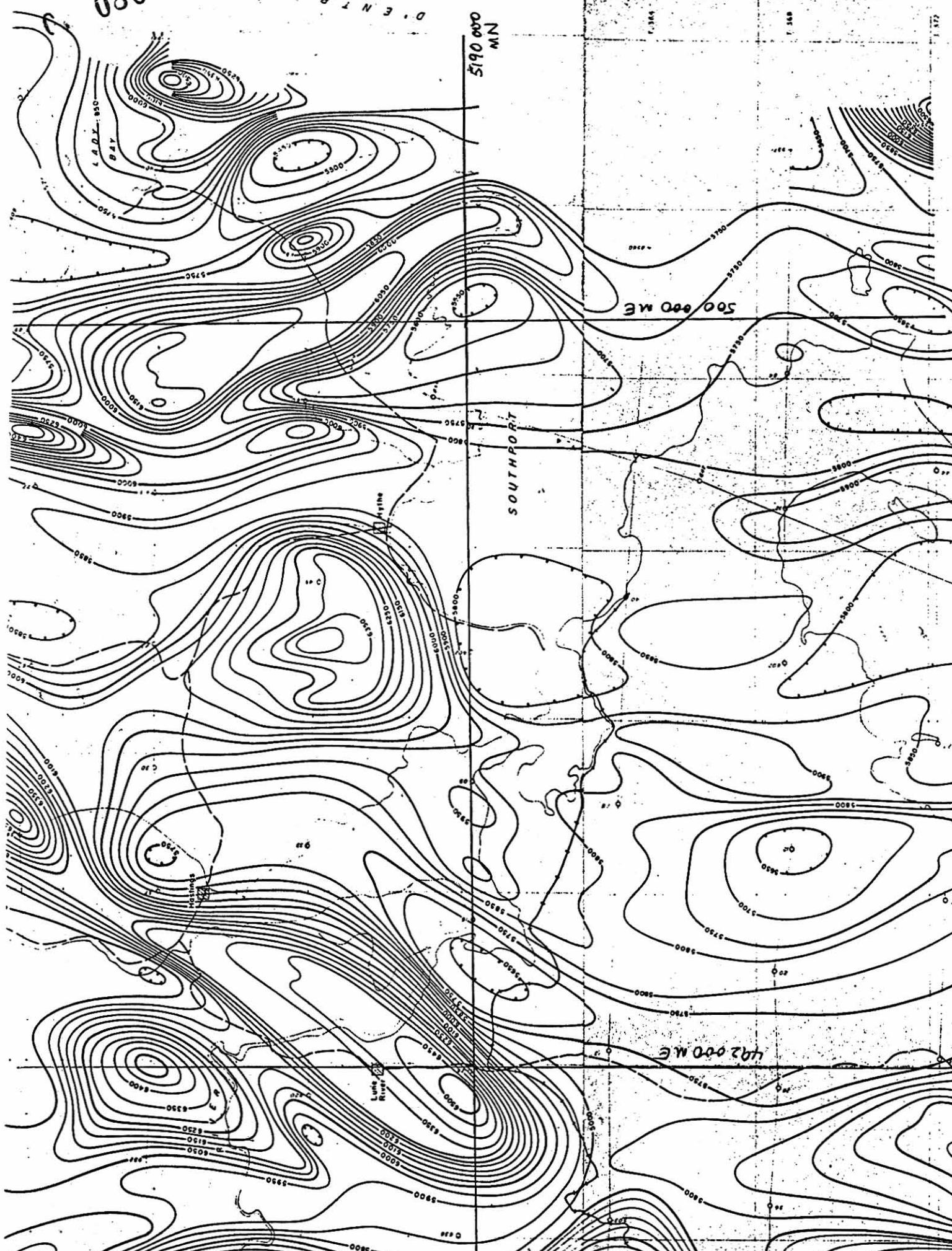
16

5190 000
NM

500 000 ME

SOUTHPORT

492 000 ME



BHP SW TASMANIA SURVEY - DETAIL: HYTHE AREA

891081



FIGURE 6



TOTAL MAGNETIC INTENSITY

SCALE

891082

IND
1:10

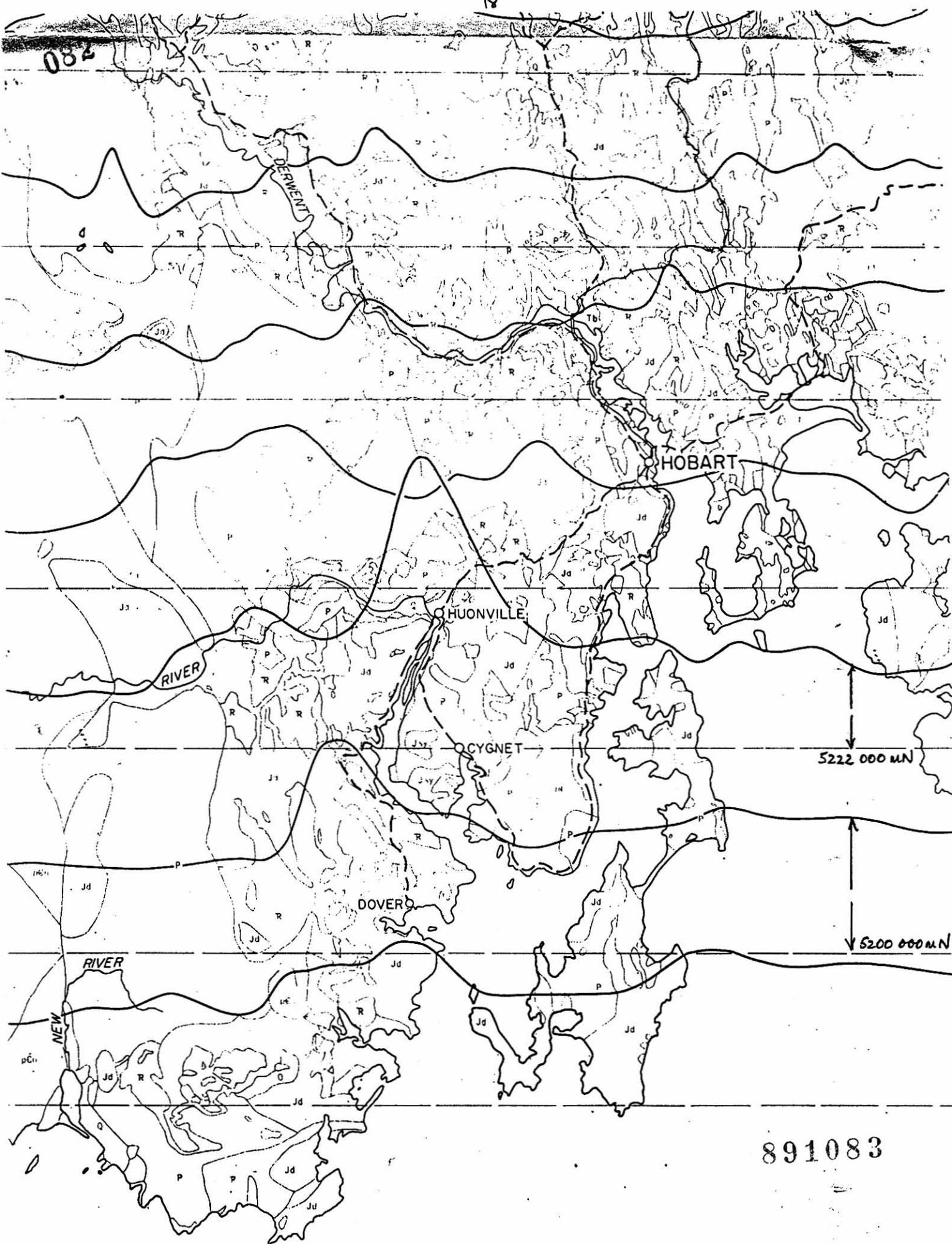
KILOMETRES



138°
36°

COMPILATION OF MAGNETIC FIELD IN SOUTHERN TASMANIA
(ALL DATA SOURCES)

FIGURE 7



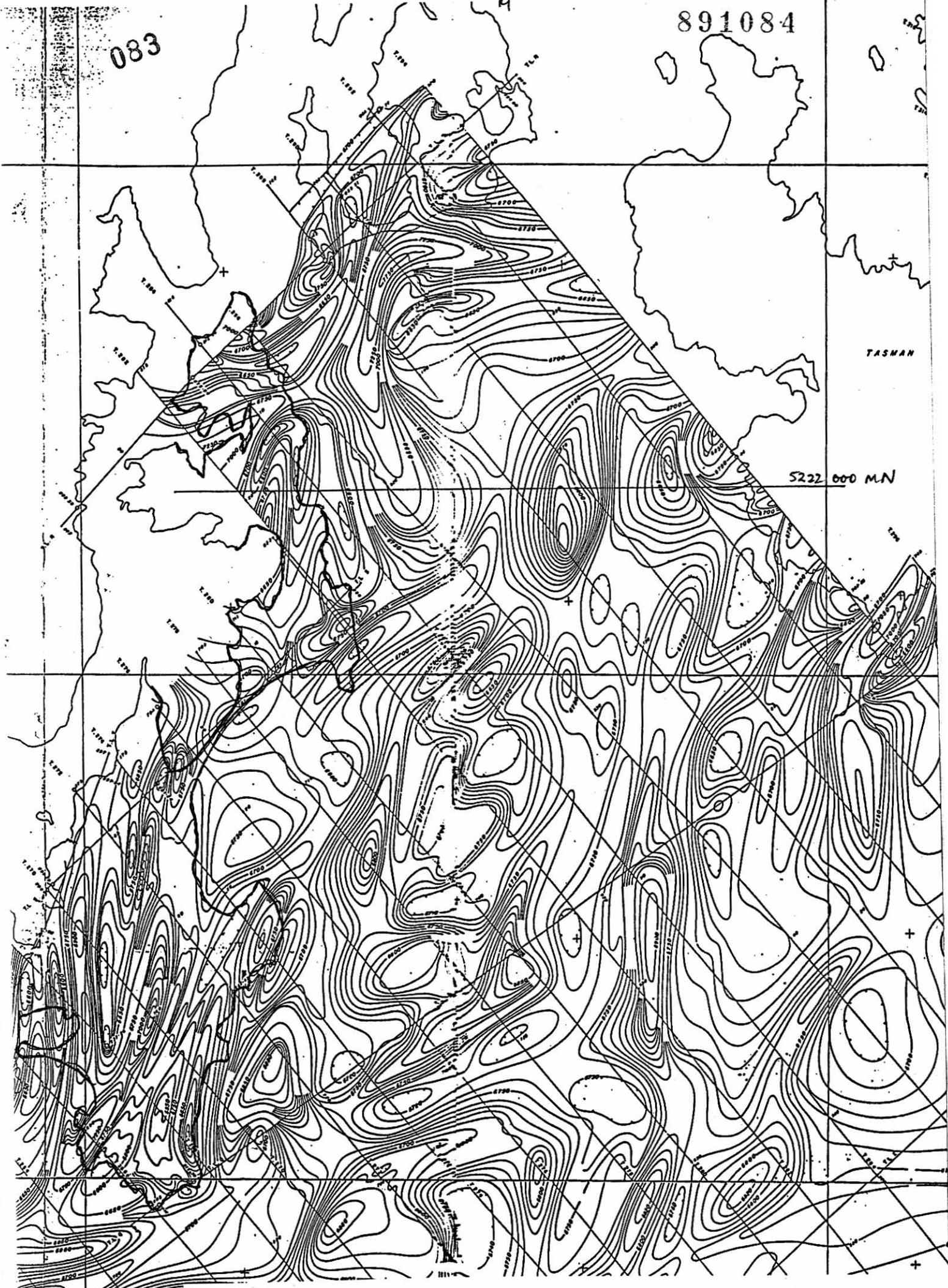
REGIONAL MAGNETIC PROFILES - BMR HIGH LEVEL SURVEY (3000 M)

FIGURE 8

083

891084

9

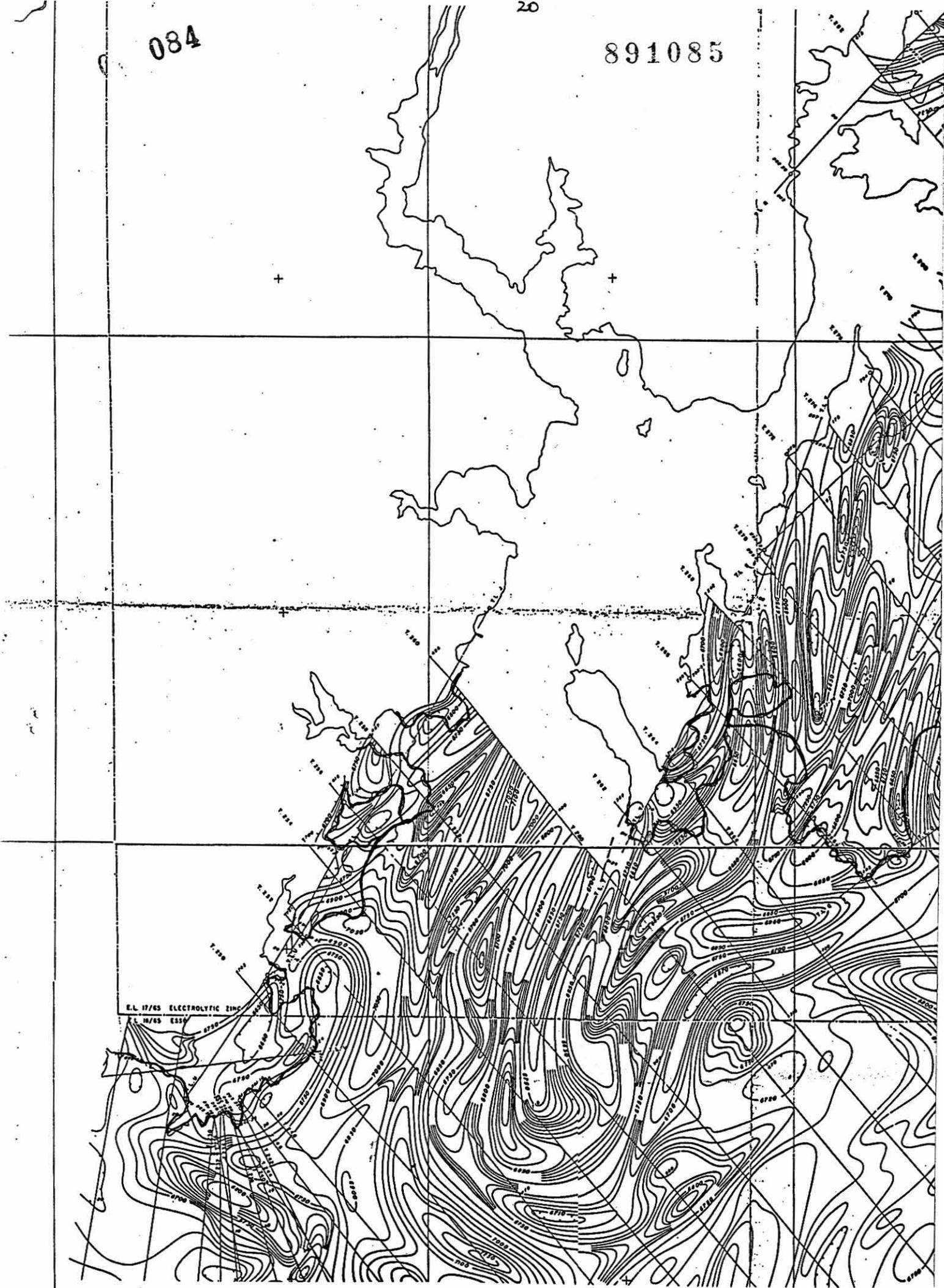


EZ MAGNETIC SURVEY - NORTHERN SECTION OF STORM BAY

084

20

891085



ESSO/EZ MAGNETIC SURVEY - SOUTHERN PART OF STORM BAY

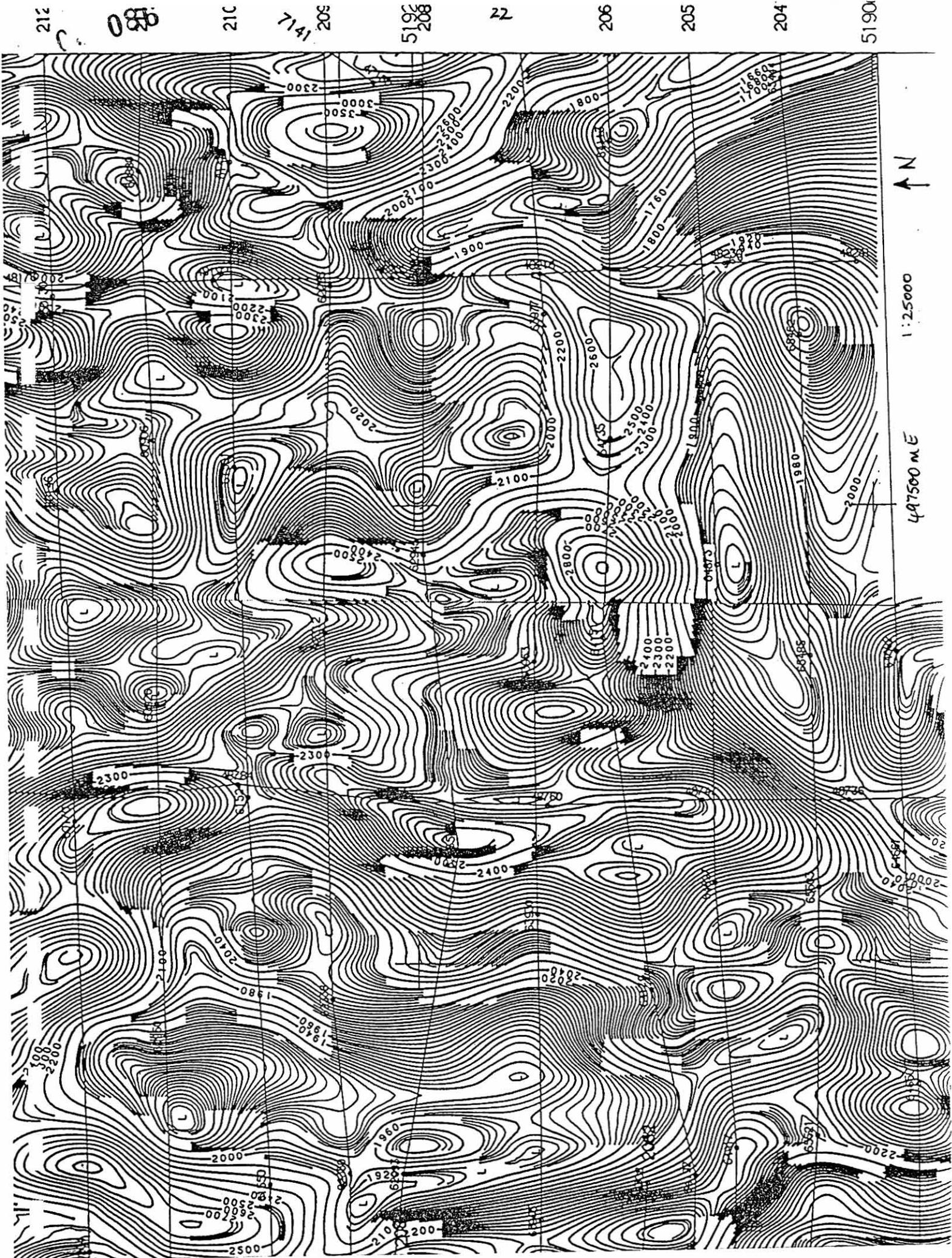
FIGURE 10

085

891086



PART OF MARINE MAGNETIC SURVEY IN D'ENTRECASTEAUX CHANNEL (FRANCOMBE, 1978)



MARATHON MAGNETIC SURVEY - CATAMARAN/STRATHBLANE AREA
 DETAIL: HYTHE AREA

891087

FIGURE 12

087

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891088

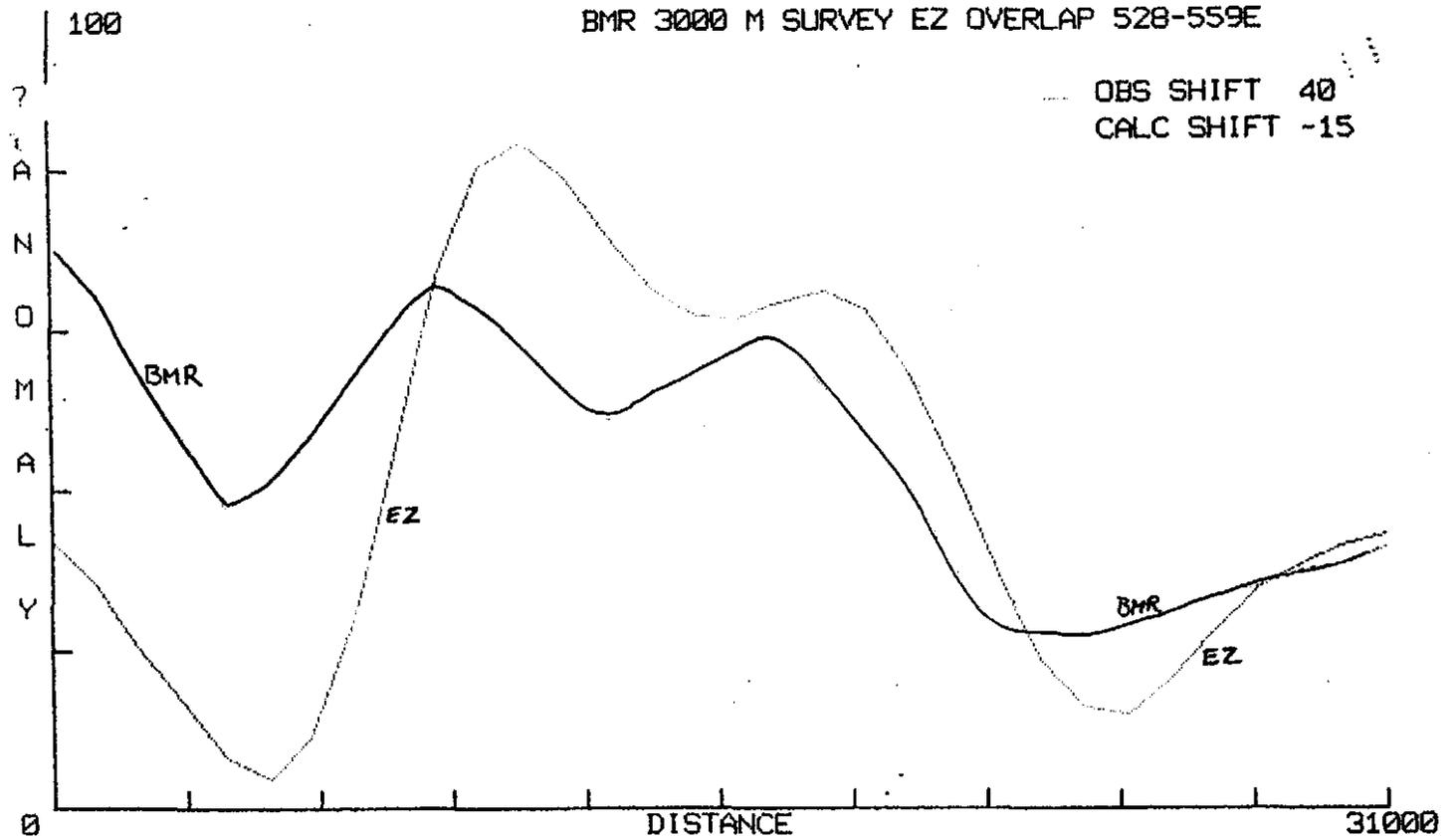
PROFILE EVALUATION LEAMAN GEOPHYSICS

0 1.00 B: EZ5222.UPC
 1 1.00 B: BMR5222.MAG

86.0	80.0	70.0	62.0	53.0	56.0	62.0
69.0	77.0	81.0	78.0	72.0	66.0	64.0
67.0	69.0	72.0	74.0	68.0	62.0	55.0
45.0	42.0	40.0	36.0	38.0	40.0	42.0
43.0	45.0	46.0	48.0			

ZERO SHIFT 0

ZERO SHIFT 0



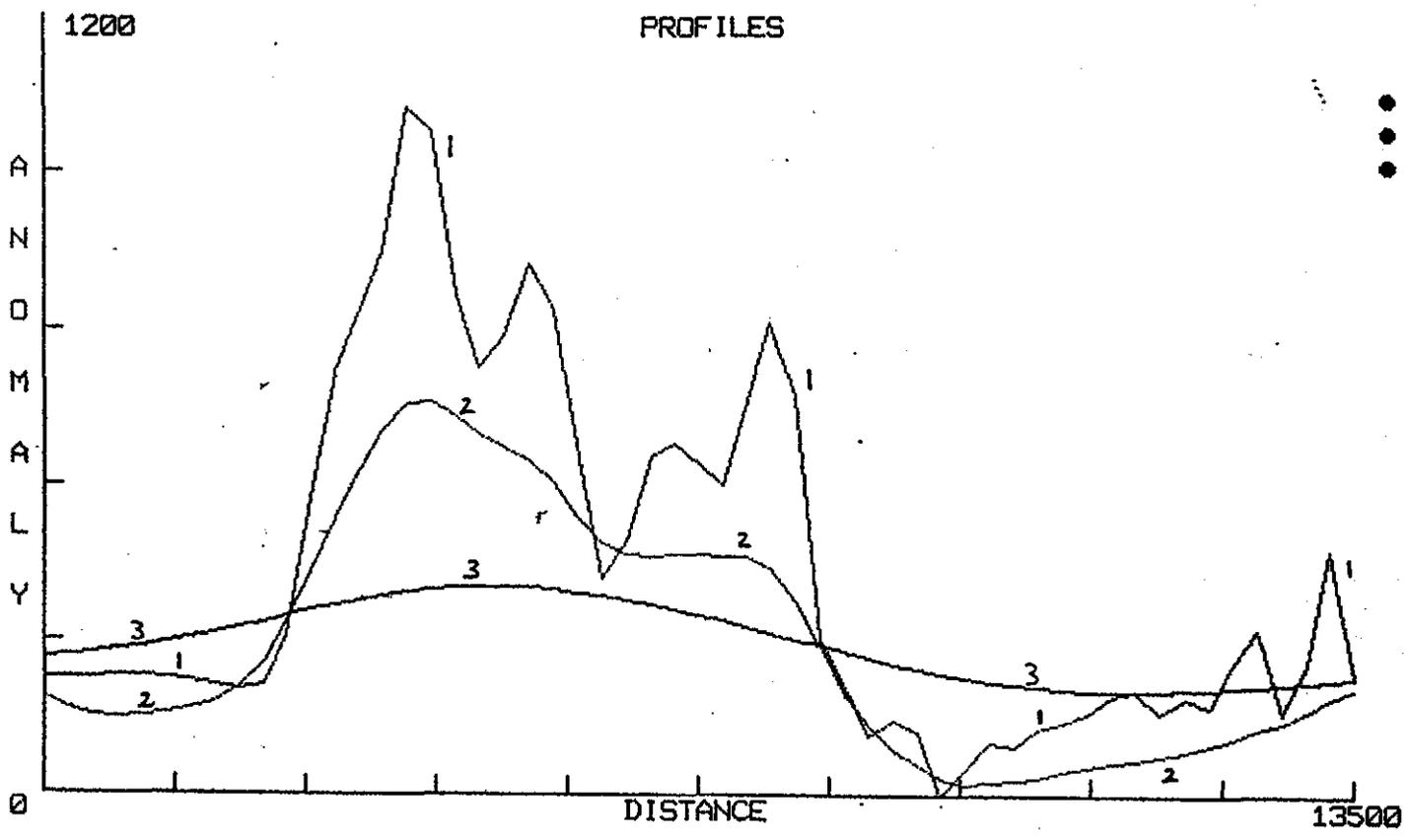
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891089

- 1 B:MAR5200.MAG MARATHON 90 M SURVEY DOVER 4891-502500 E
 - 2 B:MAR5200.UP1 MARATHON LINE 2251 UP CONTINUED TO 600 M
 - 3 B:MAR5200.UP2 MARATHON 90 M SURVEY UP CONTINUED TO 3000 M
- ZERO SHIFT : 230



MAGNETIC DATA AND CONTINUATION COMPARISONS - 5200 000 mN
MARATHON DATA LINE 2251

GRAVITY DATA

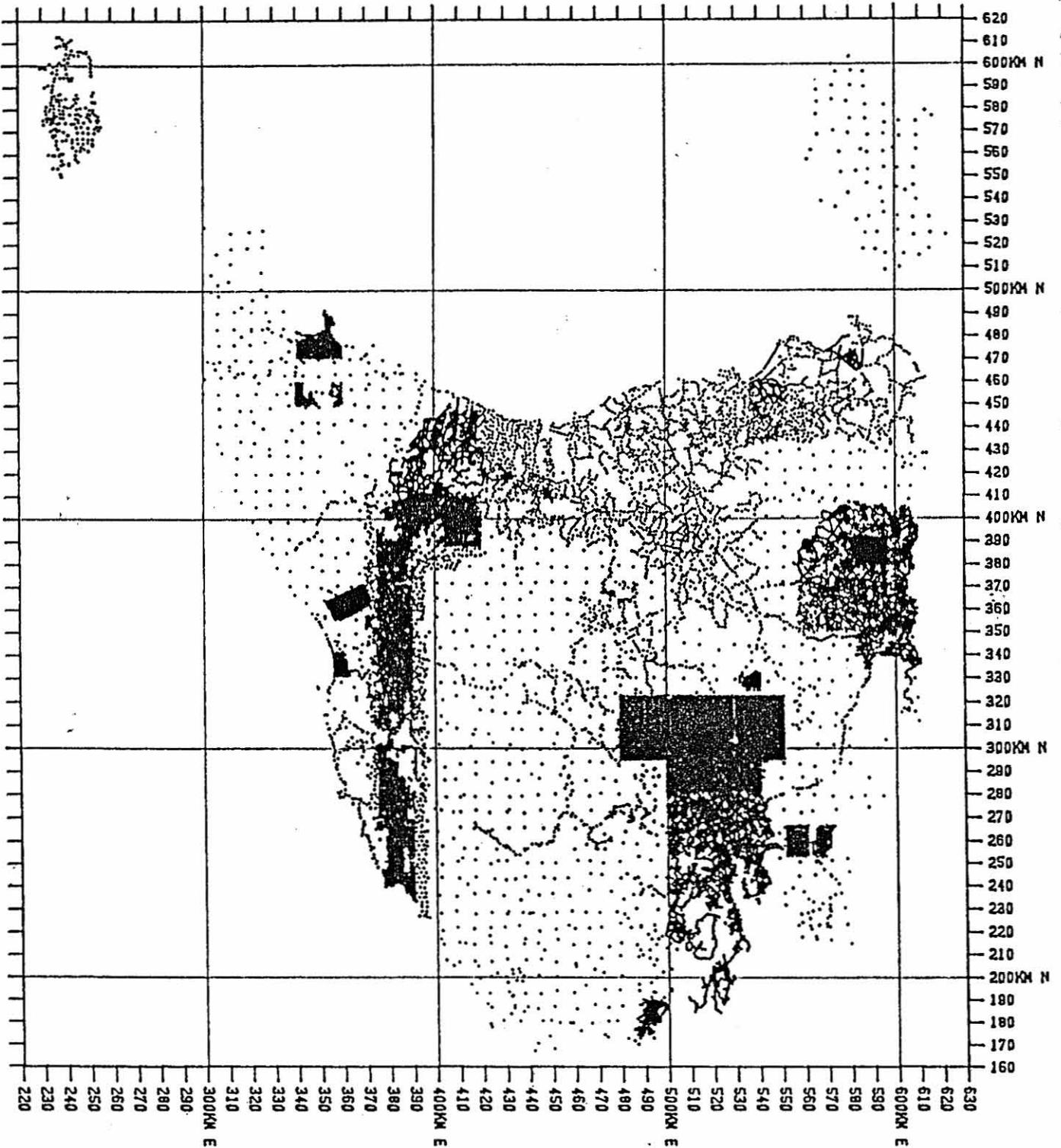
All available gravity data are held within the TASGRAV data base of the Department of Mines. All observations were recently corrected and reviewed and are adequate for structural or regional analysis. Unfortunately the data distribution is uneven (Figure 15) and the area discussed in this review is not covered in sufficient detail to define either gross structural elements or dolerite intrusions. The station density outside the area of immediate interest is even poorer. This is a problem since appreciation of the gravity field requires definition beyond the zone to be interpreted. This is discussed further in the section on interpretation.

No public domain plots of current TASGRAV data exist but an older compilation made by the Bureau of Mineral Resources from the file as at 1975 is shown in Figure 16. The present station coverage in the Channel region is not greatly changed but the present data base has now been fully corrected and some minor changes can be anticipated in any new plot.

In order to partly remedy the problem of a modern plot and to mitigate some of the effects of an irregular data distribution I have reviewed all the stations within an 80 by 80 km area which includes the expanded licence areas. Due to the many large gaps I have averaged all values within a grid of 2 x 2 km squares. This effectively minimises the effect of large near surface anomalies and disguises some of the gaps in coverage. It cannot compensate for them however, since some assumptions have to be made about the values to be inserted into the grid of points for plotting purposes. A plot of the smoothed data is shown in Figure 17. Many interpolated values have been included and even a relatively minor, or scattered, improvement in coverage might result in significant changes and no great reliance should be placed on this plot. Ideally, gaps in coverage should be no larger than necessary to resolve features at the depth of interest.

Some interpretations exist for data within or immediately adjacent to the Channel region. These include Leaman and Naqvi (1967) at Cygnet, Clark (1972) on Bruny Island, Leaman (1972) south of Hobart and Leaman (1981) at Catamaran. Only the last two can be considered reasonably reliable; the others were limited by restricted coverage and incomplete correction (now remedied). The second also suffered from inadequate interpretation assumptions. All are examples of isolated, shallow based interpretations. None considered any pre-Permian sources although Leaman (1972) referred to some basement contributions to certain anomalies.

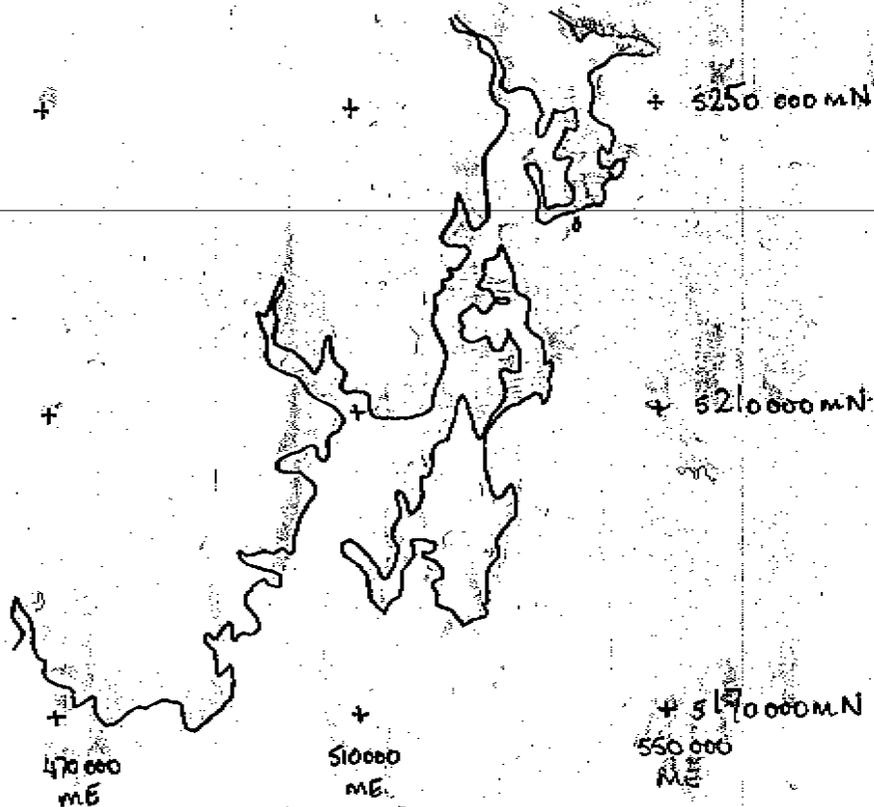
Figure 18 provides some coarser filters based on my interpolation of the data and the residuals implied for each when contrasted with the original data set. The 4 and 10 km continuations indicate the scale of basement changes. Although part of the positive gradient toward the south east is due to the edge of the continental shelf its orientation and the sizeable embayment along the line of the Huon estuary shows that the outline of the Precambrian basement core is irregular and that a considerable section of Cambrian (and other?) rocks overlies it. The spine of anomaly plunging northward from Storm Bay also suggests that large density contrasts and structures are present beneath the Permian cover.



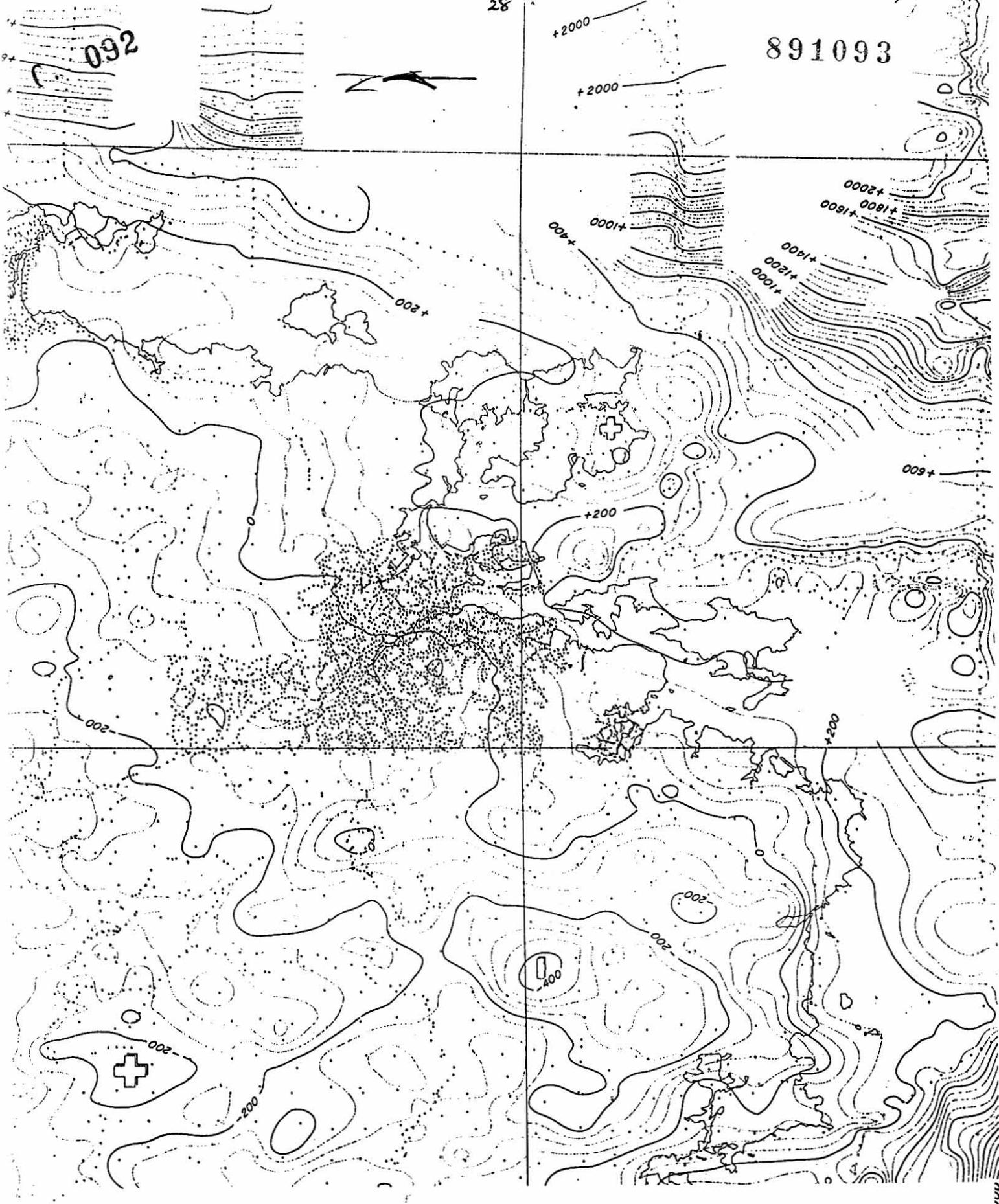
COVERAGE OF GRAVITY SURVEYS - STATIONS IN TASGRAV DATA BASE

FIGURE 15

891139.



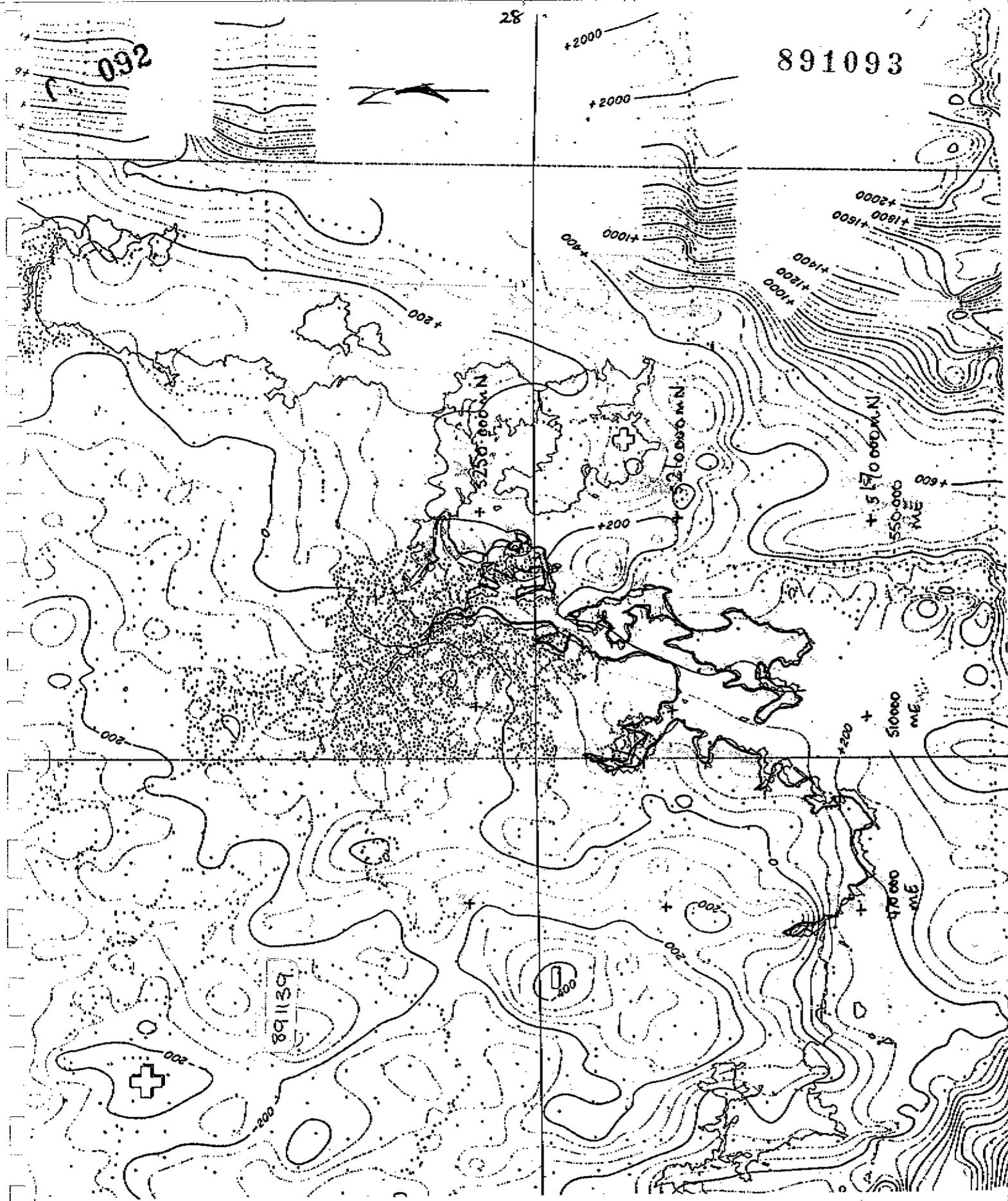
OVERLAY FOR FIGURES 16, 17 AND 18



PLOT OF GRAVITY DATA BASE AS MAINTAINED BY BMR IN 1975
SOUTH EAST TASMANIA

Note: many values subject to review and lack complete correction. TASGRAV now contains revised data. Station coverage unchanged since 1975.

FIGURE 16



PLOT OF GRAVITY DATA BASE AS MAINTAINED BY BMR IN 1975
SOUTH EAST TASMANIA

Note: many values subject to review and lack complete correction. TASGRAV now contains revised data. Station coverage unchanged since 1975.

FIGURE 16

OVERLAY FOR FIGURES 16, 17 AND 18

093

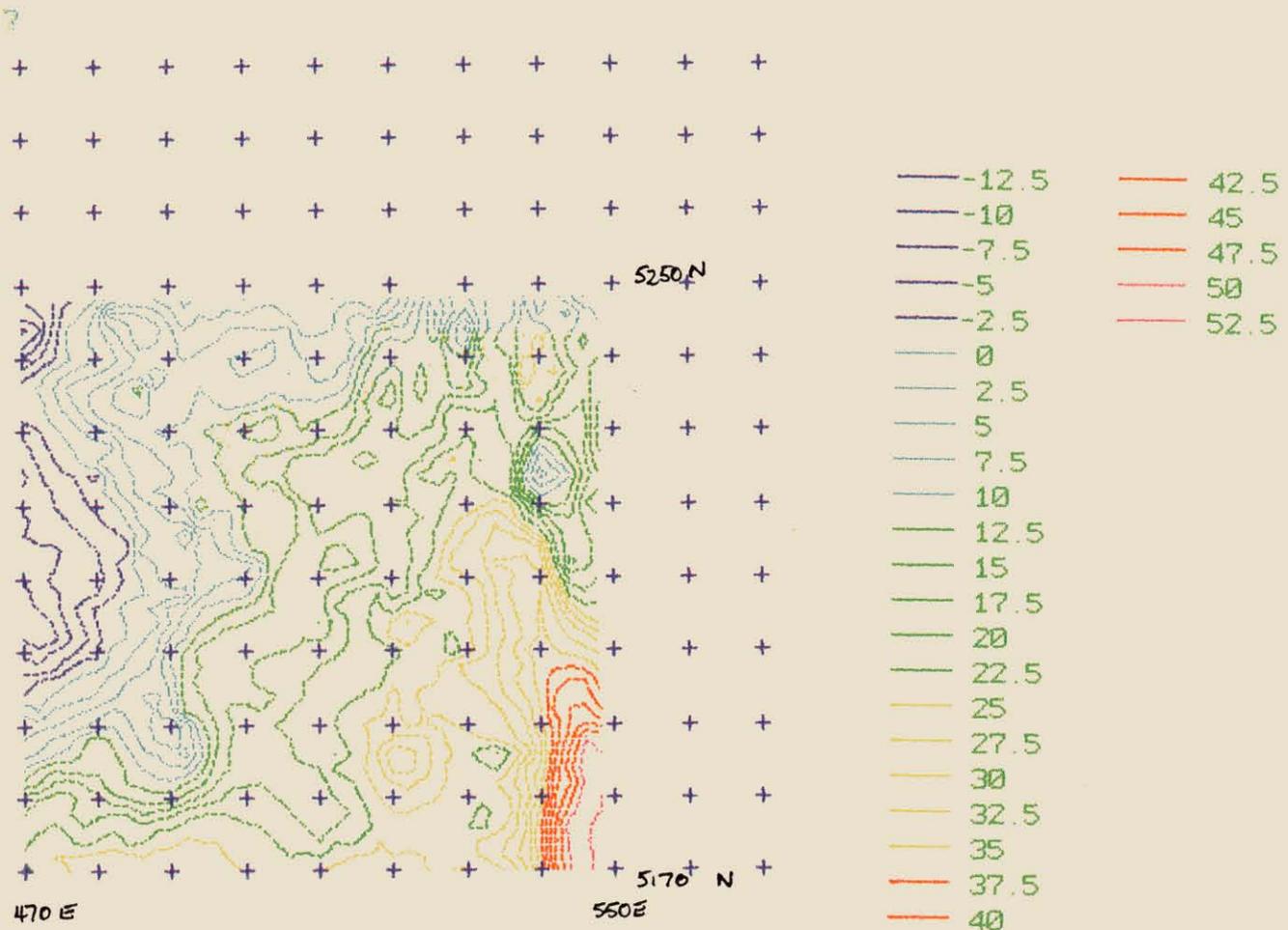
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891094

GRAVITY DATA SE TASMANIA CONGA OIL
REGIONAL GRAVITY TASGRAV DATA CONGA OIL PTY LTD
SCALE 1000000
SAMPLE SPACING 2000



GRAVITY FIELD IN SOUTH EAST TASMANIA: TASGRAV DATA BASE
Compilation by Leaman Geophysics from data base. Data filtered
by application of 2 km grid filter. Comparison with Figures 15
and 16 will indicate the number of interpolations involved.

FIGURE 17

093

LEAMAN GEOPHYSICS

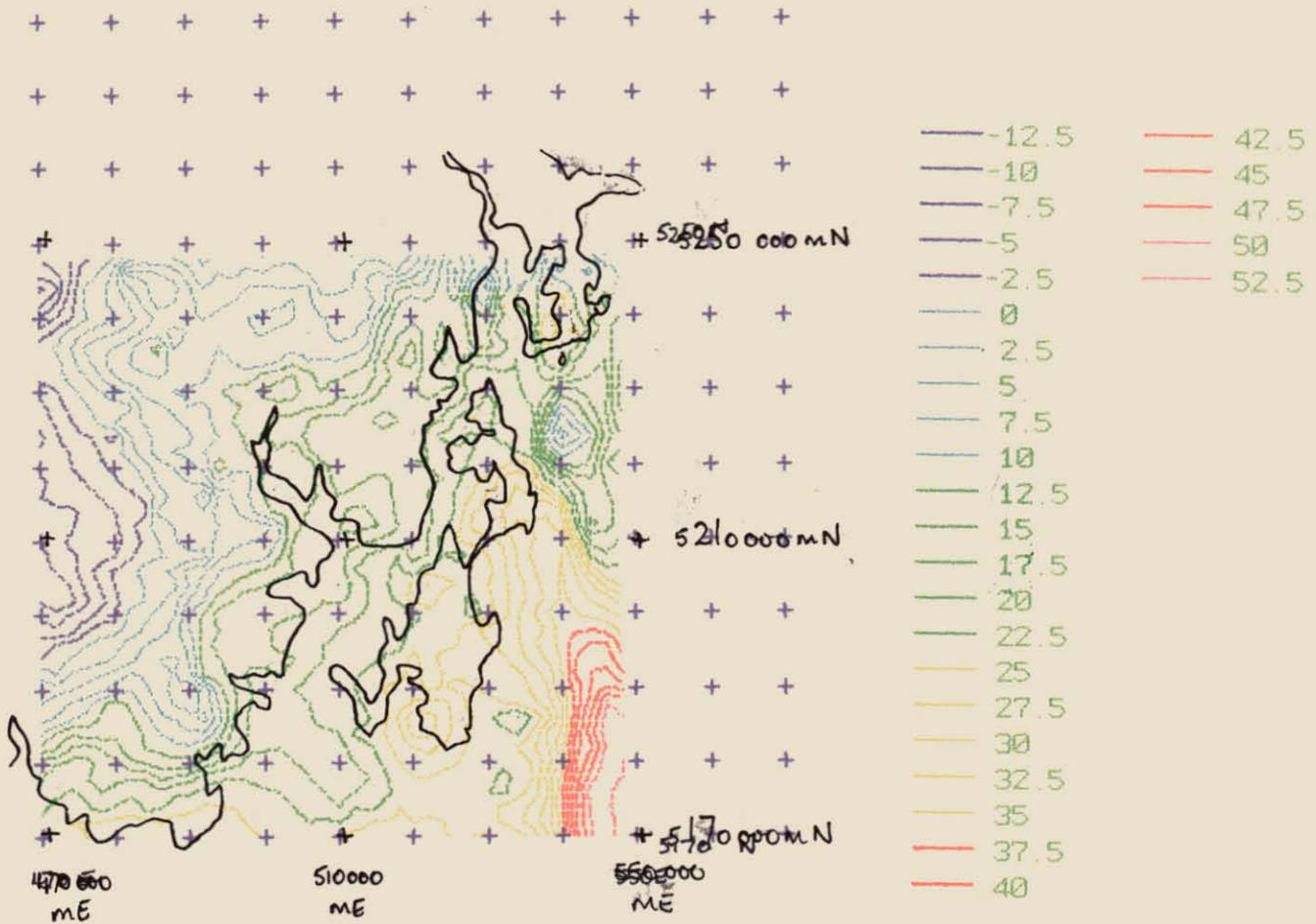
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GRAVITY DATA SE TASMANIA CONGA OIL
REGIONAL GRAVITY TASGRAV DATA CONGA OIL PTY LTD
SCALE 1000000
SAMPLE SPACING 2000

891139.



OVERLAY FOR FIGURES 16, 17 AND 18

GRAVITY FIELD IN SOUTH EAST TASMANIA: TASGRAV DATA BASE
Compilation by Leaman Geophysics from data base. Data filtered by application of 2 km grid filter. Comparison with Figures 15 and 16 will indicate the number of interpolations involved.

FIGURE 17

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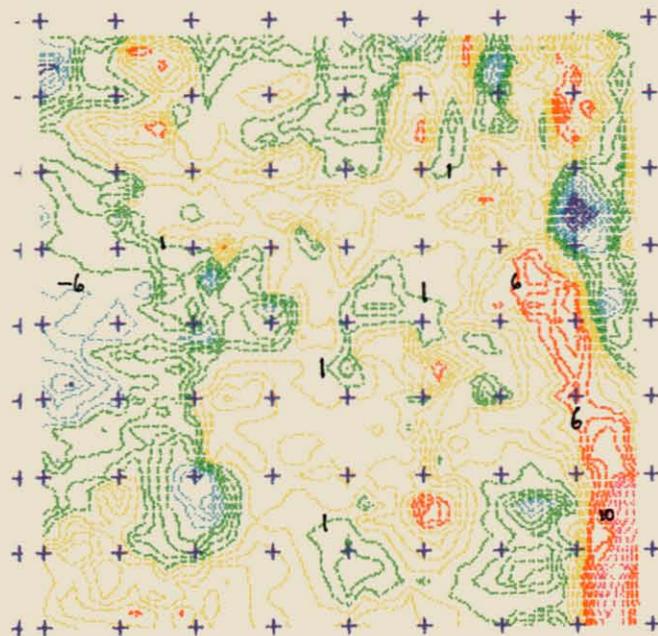
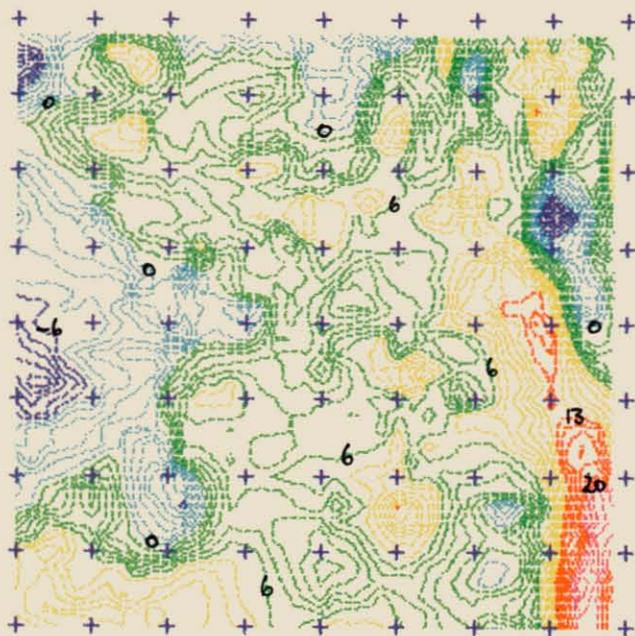
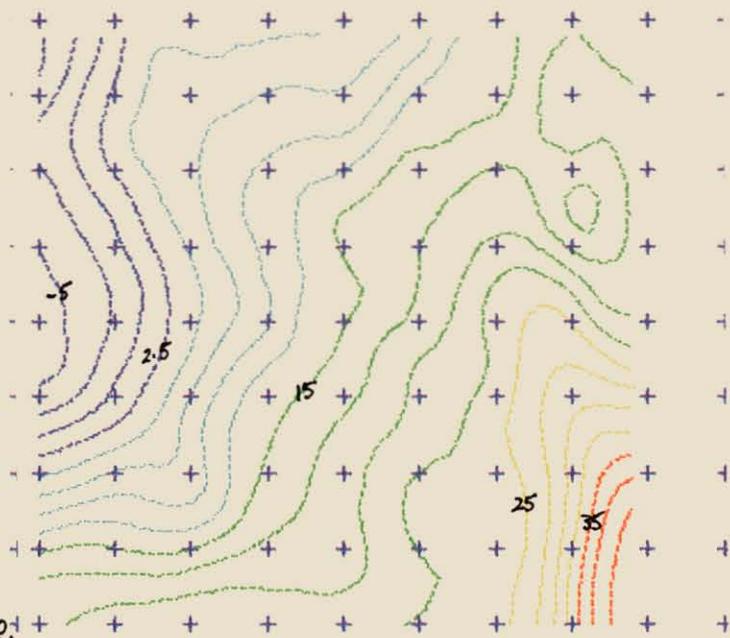
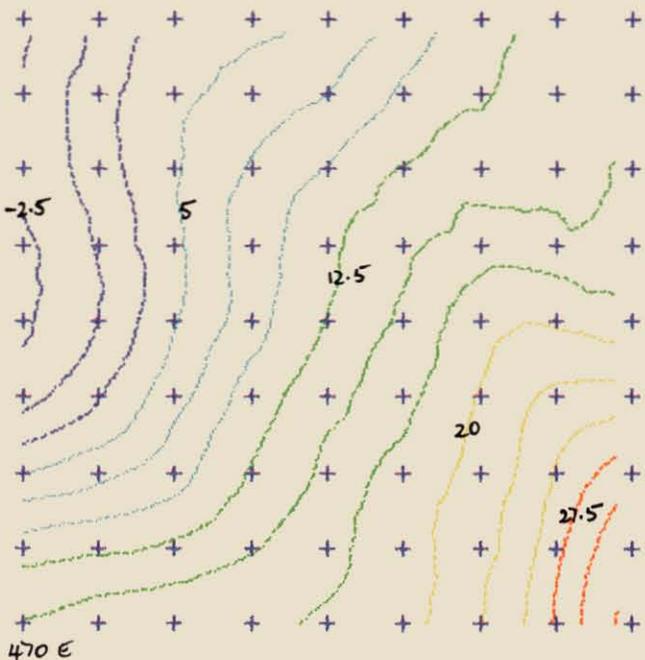
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GRAVITY DATA SE TASMANIA CONGA OIL
UPWARD CONTINUATION 10 KM
SCALE 1000000
SAMPLE SPACING 2000

GRAVITY DATA SE TASMANIA CONGA OIL
UPWARD CONTINUATION 4 KM
SCALE 1000000
SAMPLE SPACING 2000



RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 10 KM

RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 4 KM

REGIONAL AND RESIDUAL FIELD COMPARISON :TASGRAV DATA
(2 km grid - refer to Figure 17 for original presentation)

LEAMAN GEOPHYSICS

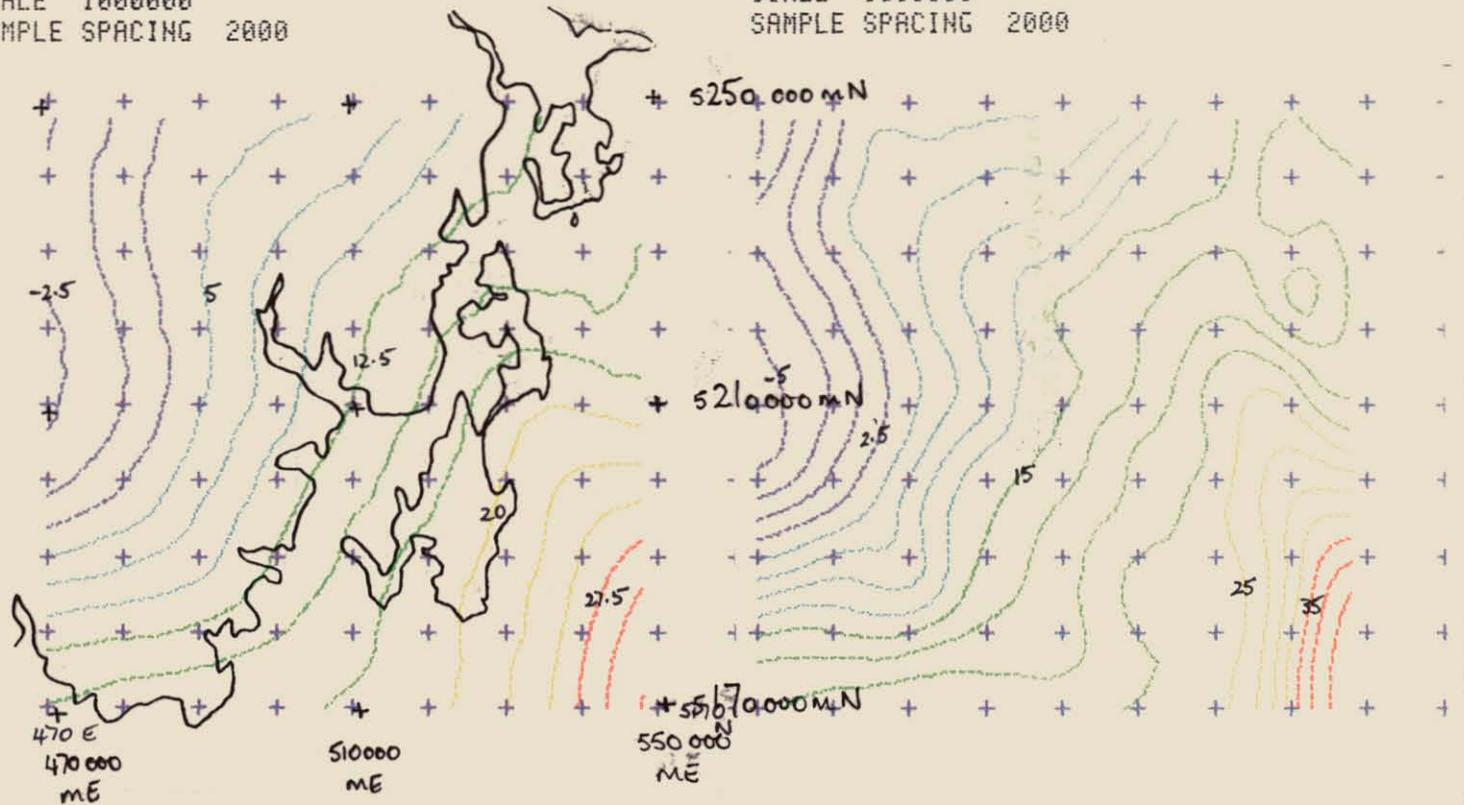
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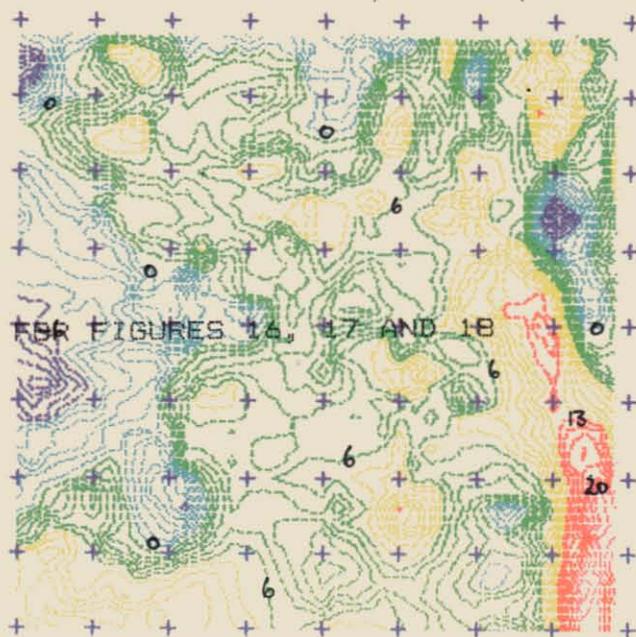
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GRAVITY DATA SE TASMANIA CONGA OIL
UPWARD CONTINUATION 10 KM
SCALE 1000000
SAMPLE SPACING 2000

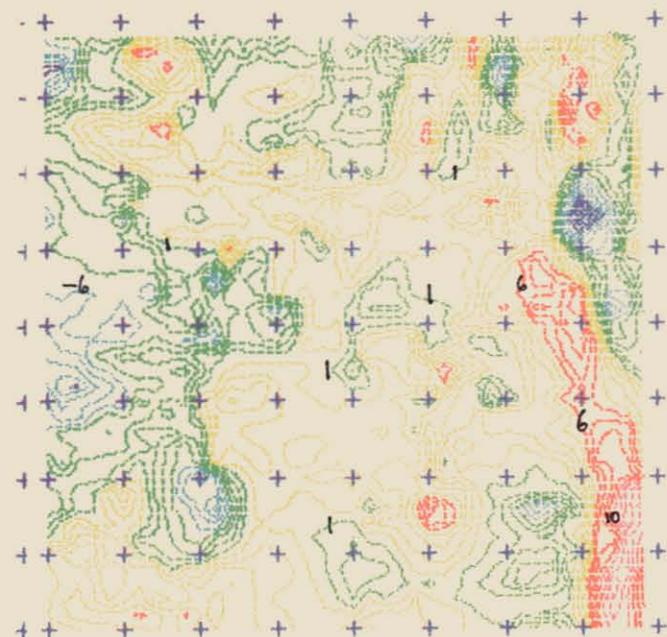
GRAVITY DATA SE TASMANIA CONGA OIL
UPWARD CONTINUATION 4 KM
SCALE 1000000
SAMPLE SPACING 2000



OVERLAY FOR FIGURES 14, 17 AND 18



RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 10 KM



RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 4 KM

REGIONAL AND RESIDUAL FIELD COMPARISON :TASGRAV DATA
(2 km grid - refer to Figure 17 for original presentation)

FIGURE 18

LEAMAN GEOPHYSICS

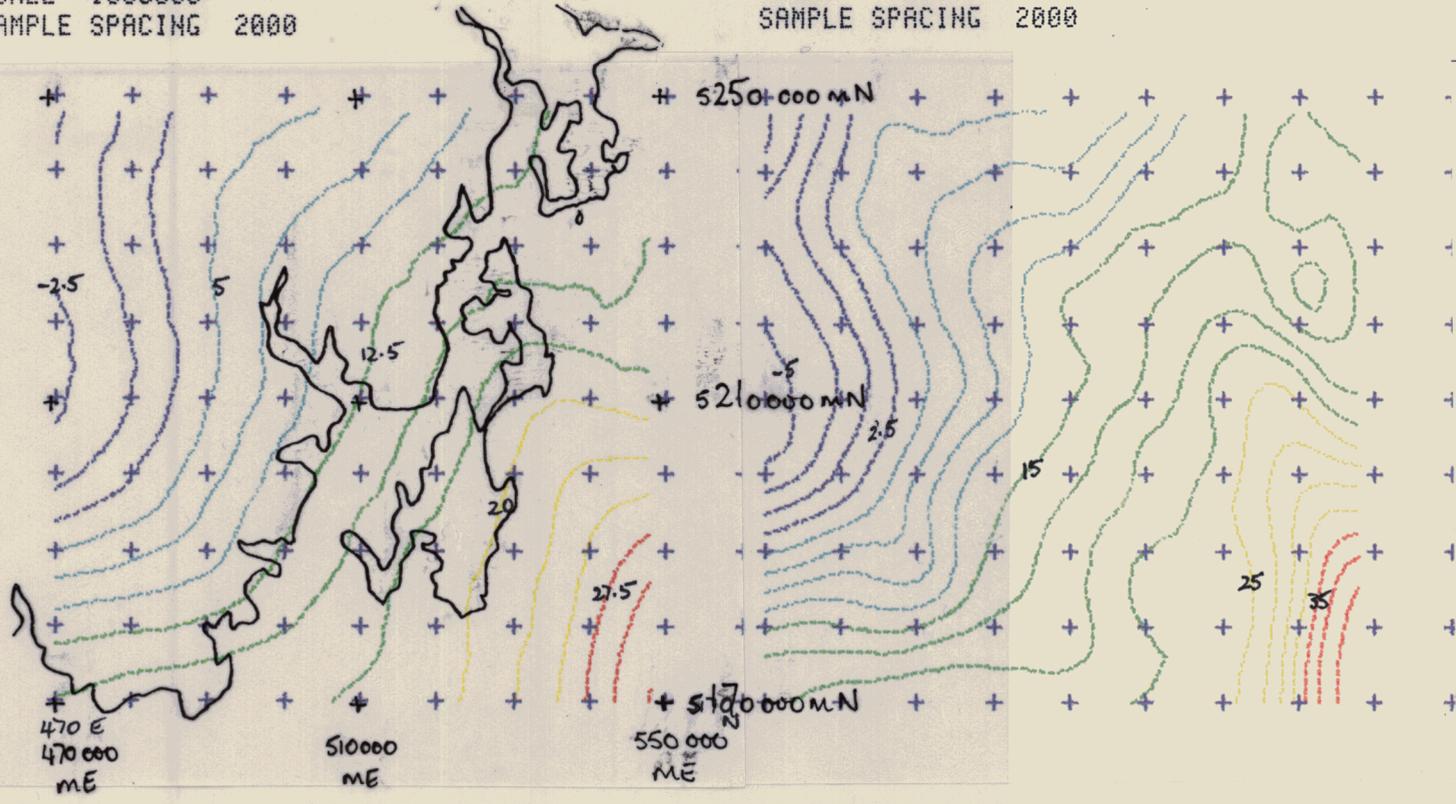
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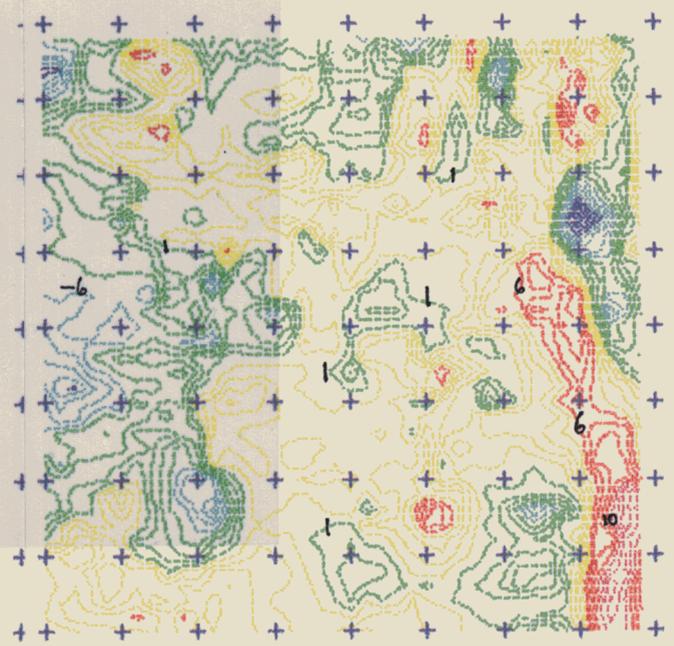
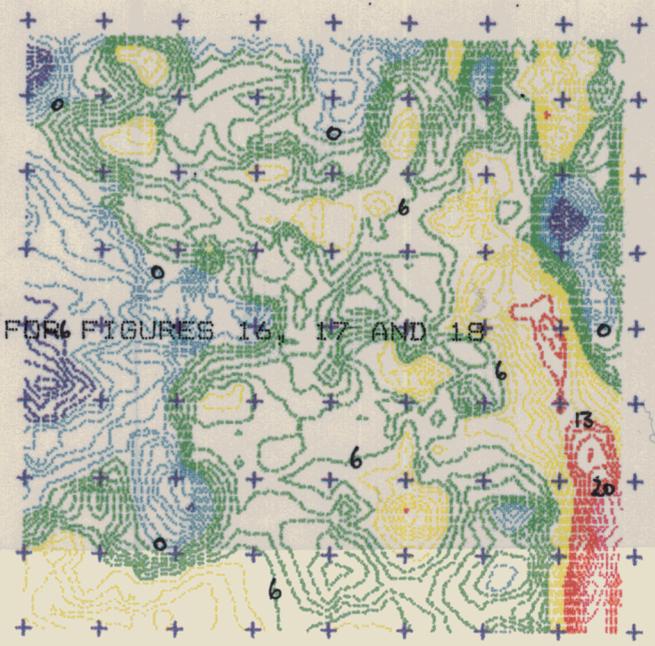
891139.

GRAVITY DATA SE TASMANIA CONGA OIL
UPWARD CONTINUATION 10 KM
SCALE 1000000
SAMPLE SPACING 2000

GRAVITY DATA SE TASMANIA CONGA OIL
UPWARD CONTINUATION 4 KM
SCALE 1000000
SAMPLE SPACING 2000



OVERLAY FOR FIGURES 16, 17 AND 19



RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 10 KM

RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 4 KM

REGIONAL AND RESIDUAL FIELD COMPARISON :TASGRAV DATA
(2 km grid - refer to Figure 17 for original presentation)

FIGURE 18

094

891095

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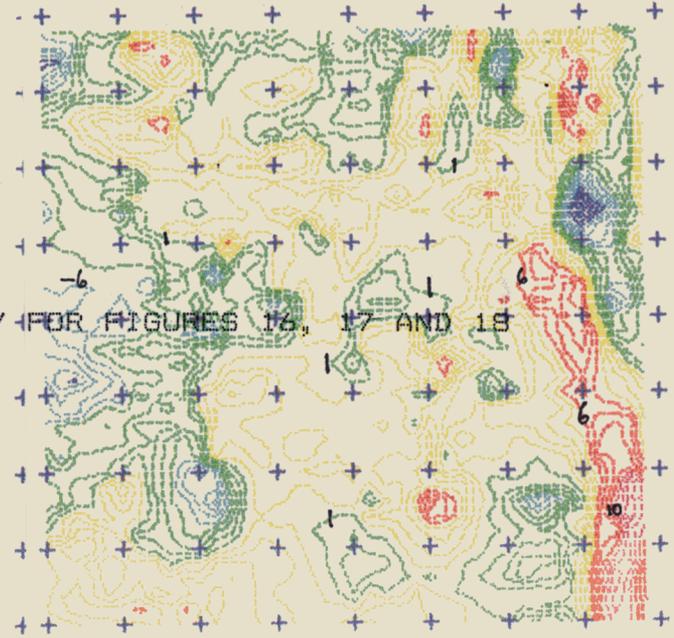
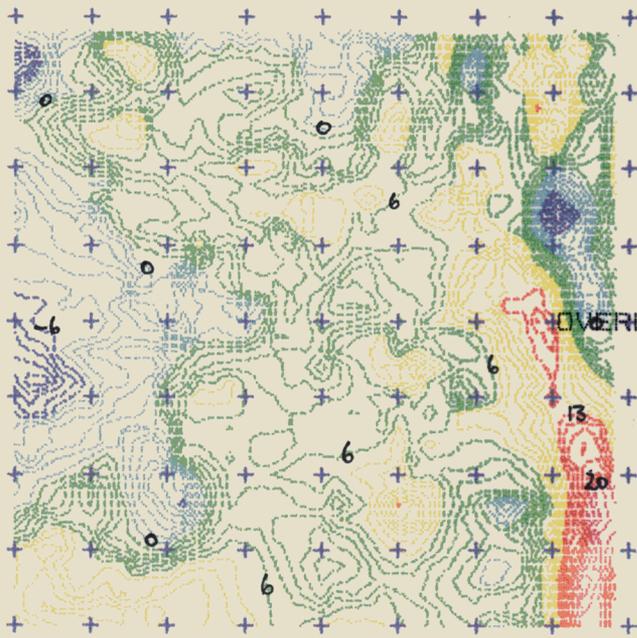
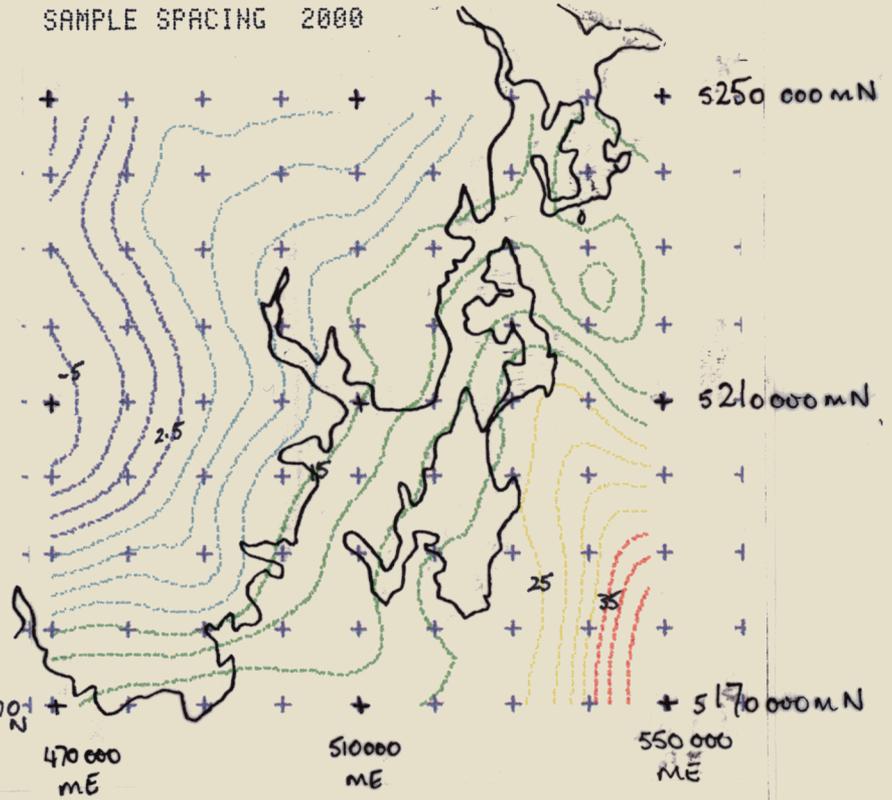
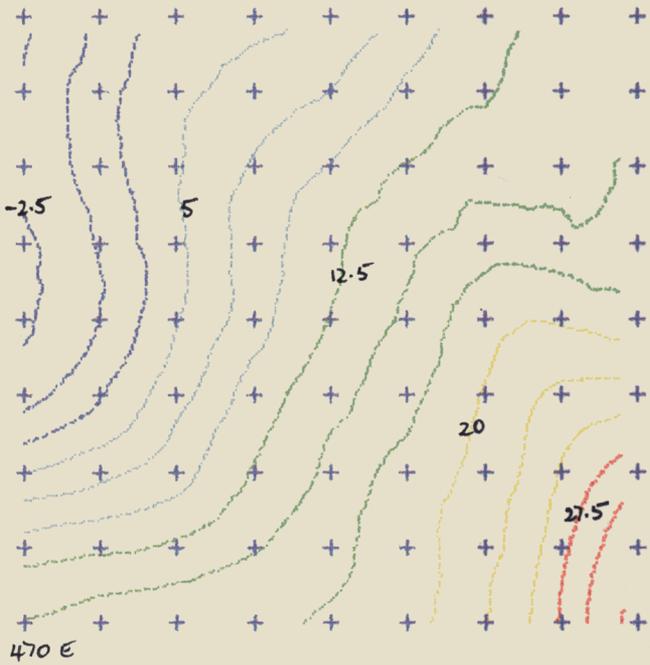
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GRAVITY DATA SE TASMANIA CONGA OIL
UPWARD CONTINUATION 10 KM
SCALE 1000000
SAMPLE SPACING 2000

GRAVITY DATA SE TASMANIA CONGA OIL
UPWARD CONTINUATION 4 KM
SCALE 1000000
SAMPLE SPACING 2000



OVERLAY FOR FIGURES 16, 17 AND 18

RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 10 KM

RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 4 KM

REGIONAL AND RESIDUAL FIELD COMPARISON :TASGRAV DATA
(2 km grid - refer to Figure 17 for original presentation)

FIGURE 18

LEAMAN GEOPHYSICS

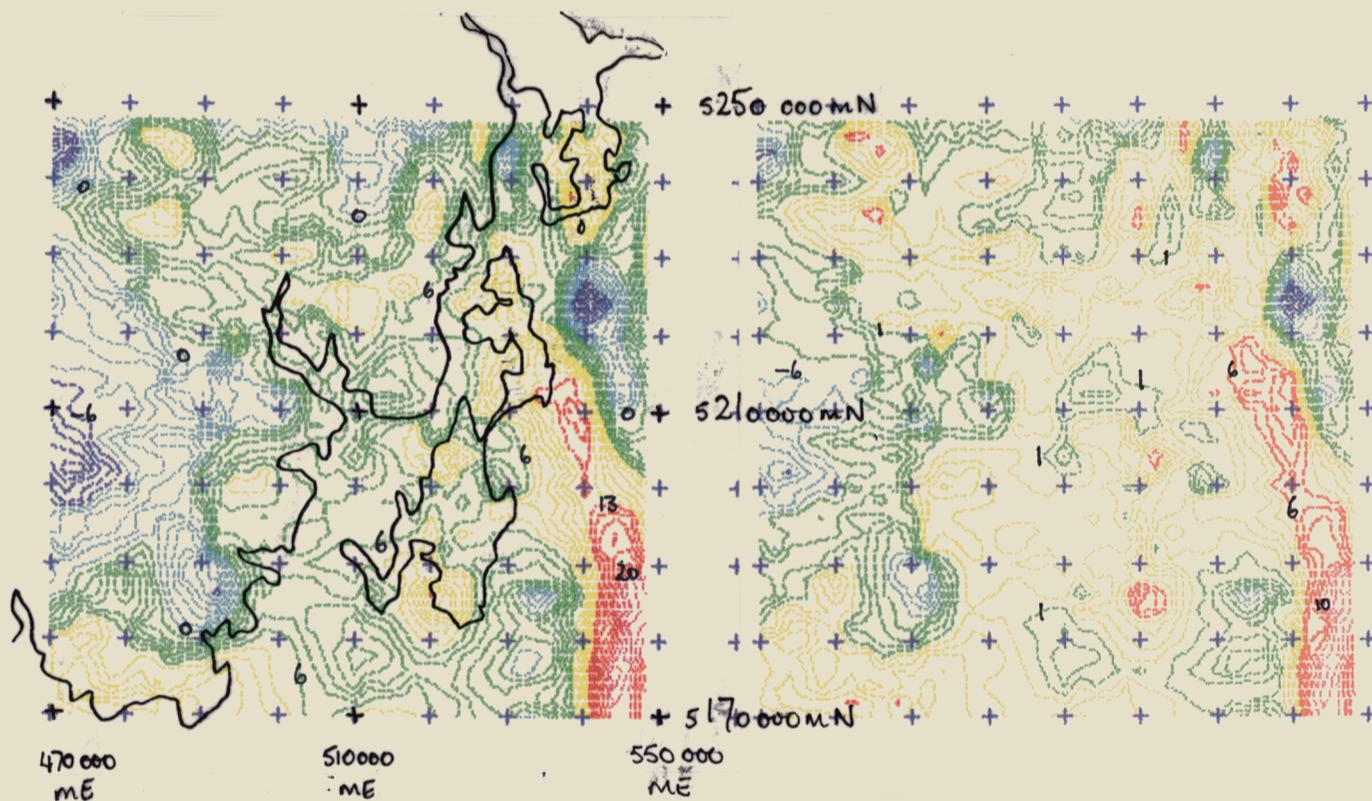
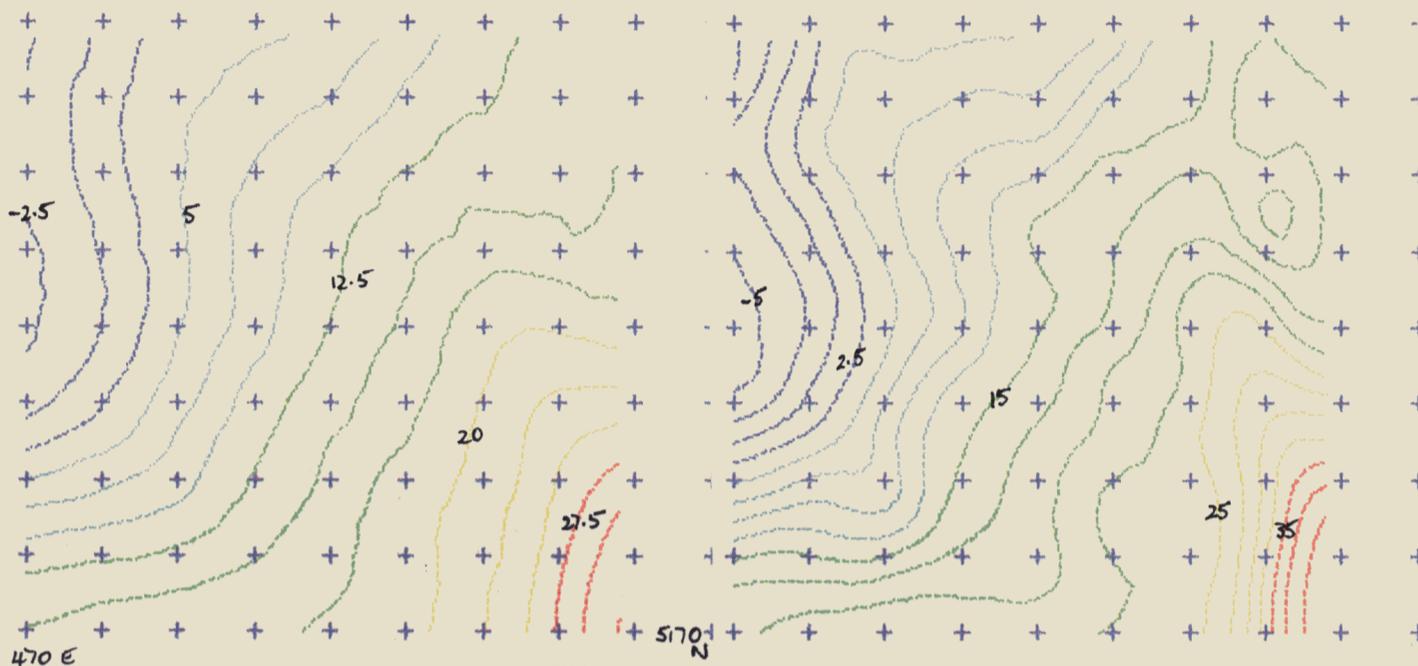
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UPWARD CONTINUATION 10 KM
SCALE 1000000
SAMPLE SPACING 2000

GRAVITY DATA SE TASMANIA CONGA OIL
UPWARD CONTINUATION 4 KM
SCALE 1000000
SAMPLE SPACING 2000

891139.



RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 10 KM

RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 4 KM

REGIONAL AND RESIDUAL FIELD COMPARISON : TASGRAV DATA
(2 km grid - refer to Figure 17 for original presentation)

FIGURE 18

OVERLAY FOR FIGURES 16, 17 AND 18

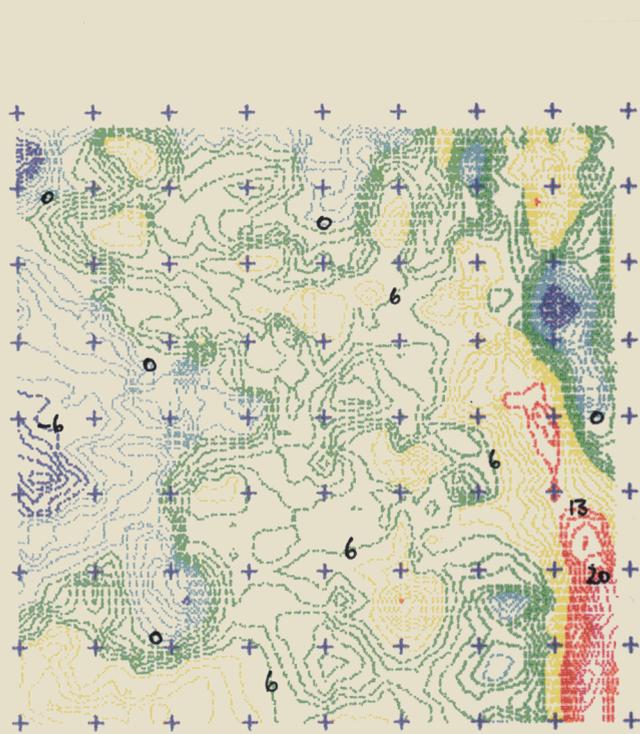
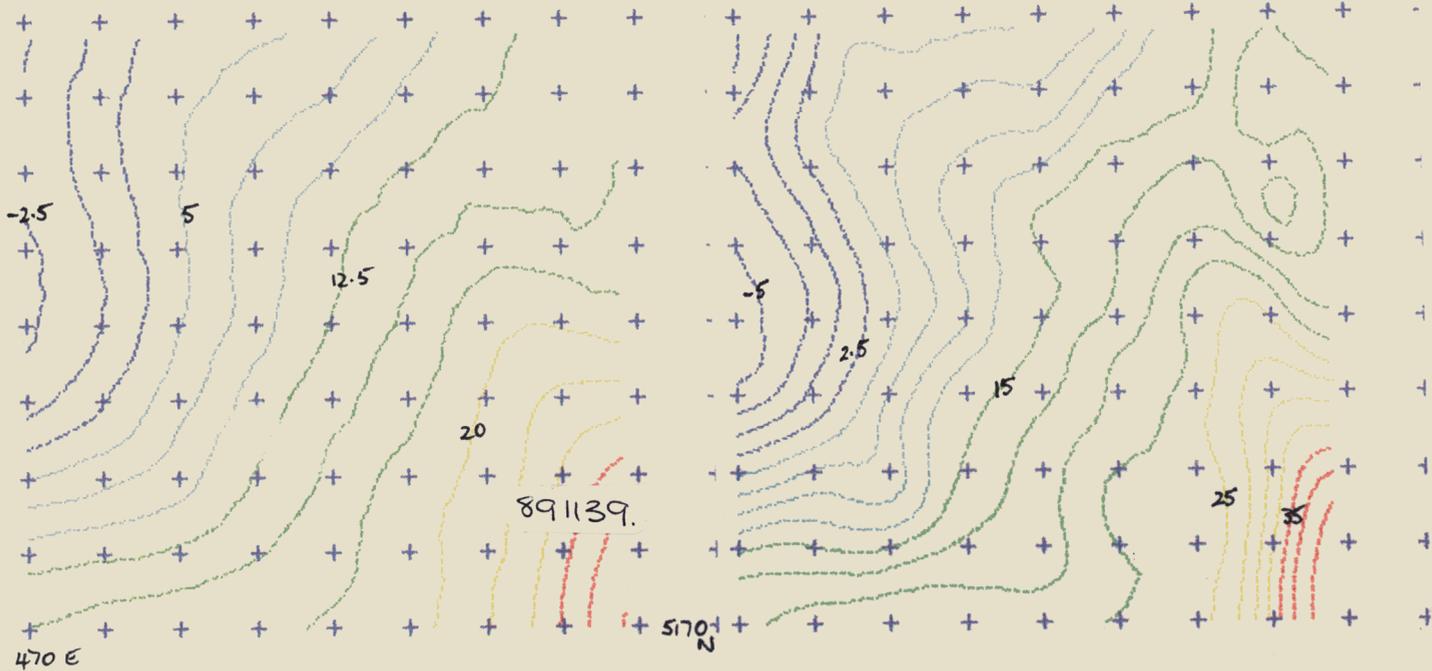
LEAMAN GEOPHYSICS

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Specialties:- Gravity, Magnetics, Seismic Methods

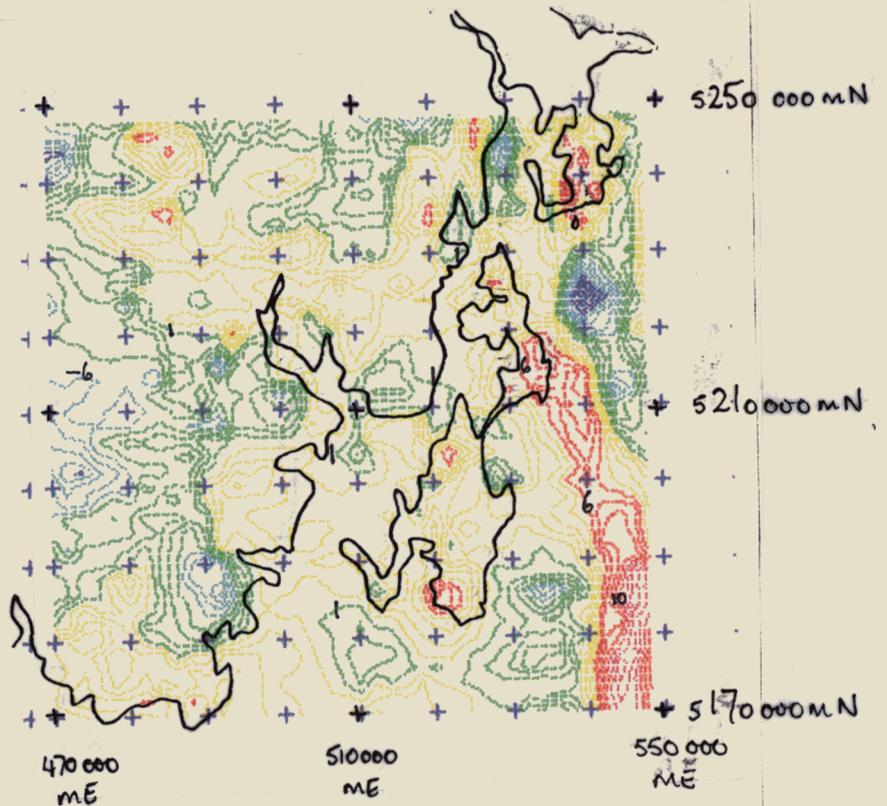
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GRAVITY DATA SE TASMANIA CONGA OIL
UPWARD CONTINUATION 10 KM
SCALE 1000000
SAMPLE SPACING 2000

GRAVITY DATA SE TASMANIA CONGA OIL
UPWARD CONTINUATION 4 KM
SCALE 1000000
SAMPLE SPACING 2000



RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 10 KM



RESIDUAL ANOMALY
DATA VS UPWARD CONTINUATION 4 KM

REGIONAL AND RESIDUAL FIELD COMPARISON : TASGRAV DATA
(2 km grid - refer to Figure 17 for original presentation)

FIGURE 18

OVERLAY FOR FIGURES 16, 17 AND 18

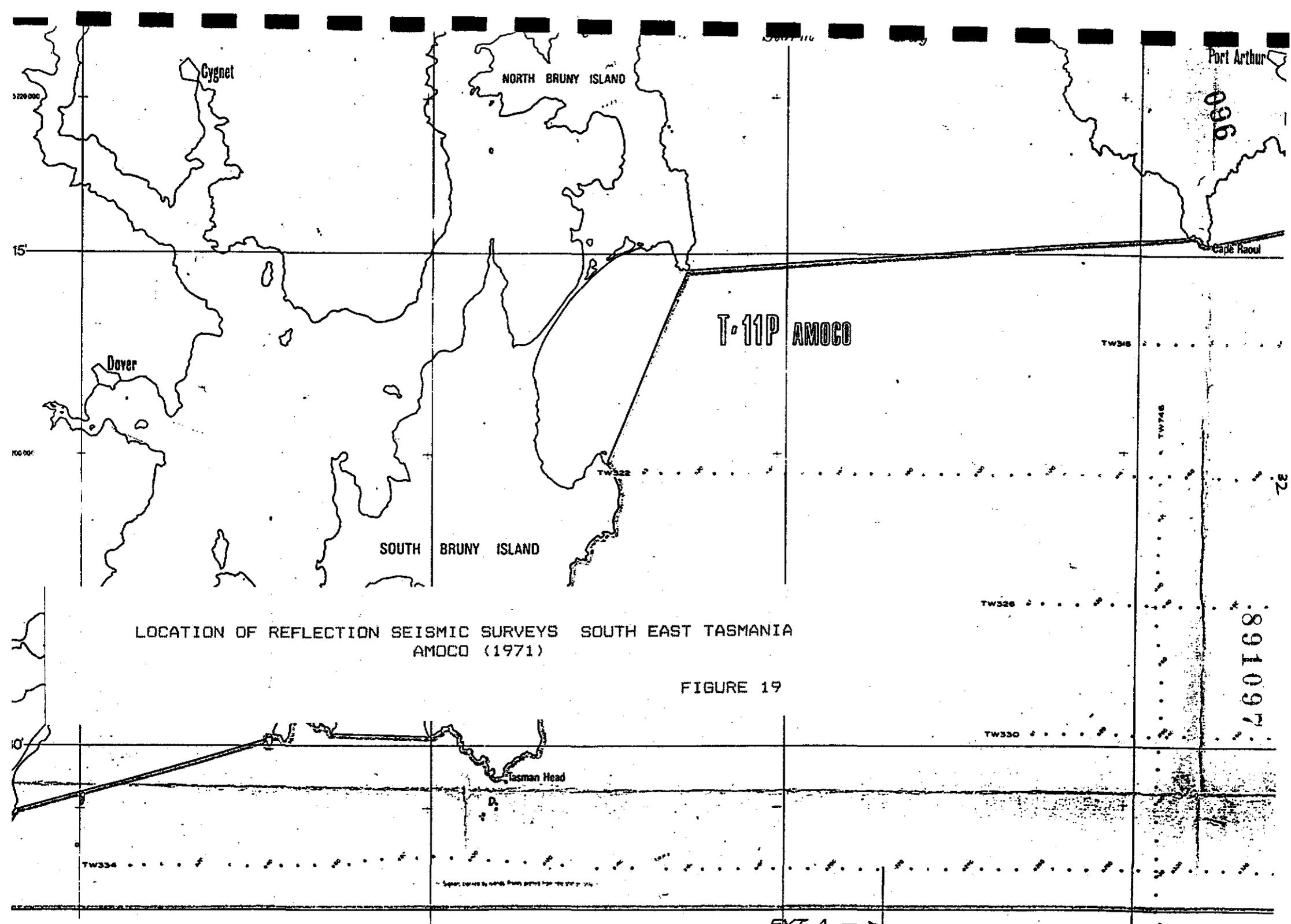
SEISMIC DATA

Very little seismic data is available for South east Tasmania. Most surveys have used the refraction method for evaluation of shallow weathering or location of Tertiary channels. None of this work is relevant to the present study. The only reflection coverage is indicated in Figure 19. This 1971 survey (Amoco, 1971) was anchored on Bruny Island but concentrated on the region east of Storm Bay. From a coverage viewpoint it offers little to the present study other than an indication of specification.

The two relevant E-W lines have been reproduced in Figures 20 and 21. Data quality is poor and little can be discerned beneath the strong reflector near the bay floor. This is almost certainly due to the change from low velocity recent and Tertiary sediments to high velocity Permian units or dolerite. The impulse energy was insufficient to generate deeper reflections beneath this reflector and other structures are thus shadowed. Reflectors are rarely noted below 0.4 s except where the bay sediments thicken. Amoco considered this sea floor reflector to represent economic basement.

On line 322 there is a thin layer of sea floor silt and variable amounts of underlying sediment. Most of the sediment appears to occupy erosional channels with little significant faulting west of shot point 63. Some channels may contain 150 to 300 m of material.

On line 334 the character is similar but a relatively deep and apparently fault controlled half graben is evident between shot points 27 and 42 (from Channel centre to Cape Bruny) with up to 500 m of contained sediment. A shallower erosional depression occurs south of Cloudy Bay and pre-Tertiary rocks outcrop on the bay floor until several kilometres east of Tasman Head where the section begins to systematically thicken to the east.



LOCATION OF REFLECTION SEISMIC SURVEYS SOUTH EAST TASMANIA
AMOCO (1971)

FIGURE 19

Port Arthur

Cygnet

NORTH BRUNY ISLAND

096

Cape Raoul

T-11P AMOCO

TW348

TW349

32

TW322

SOUTH BRUNY ISLAND

TW326

891097

TW330

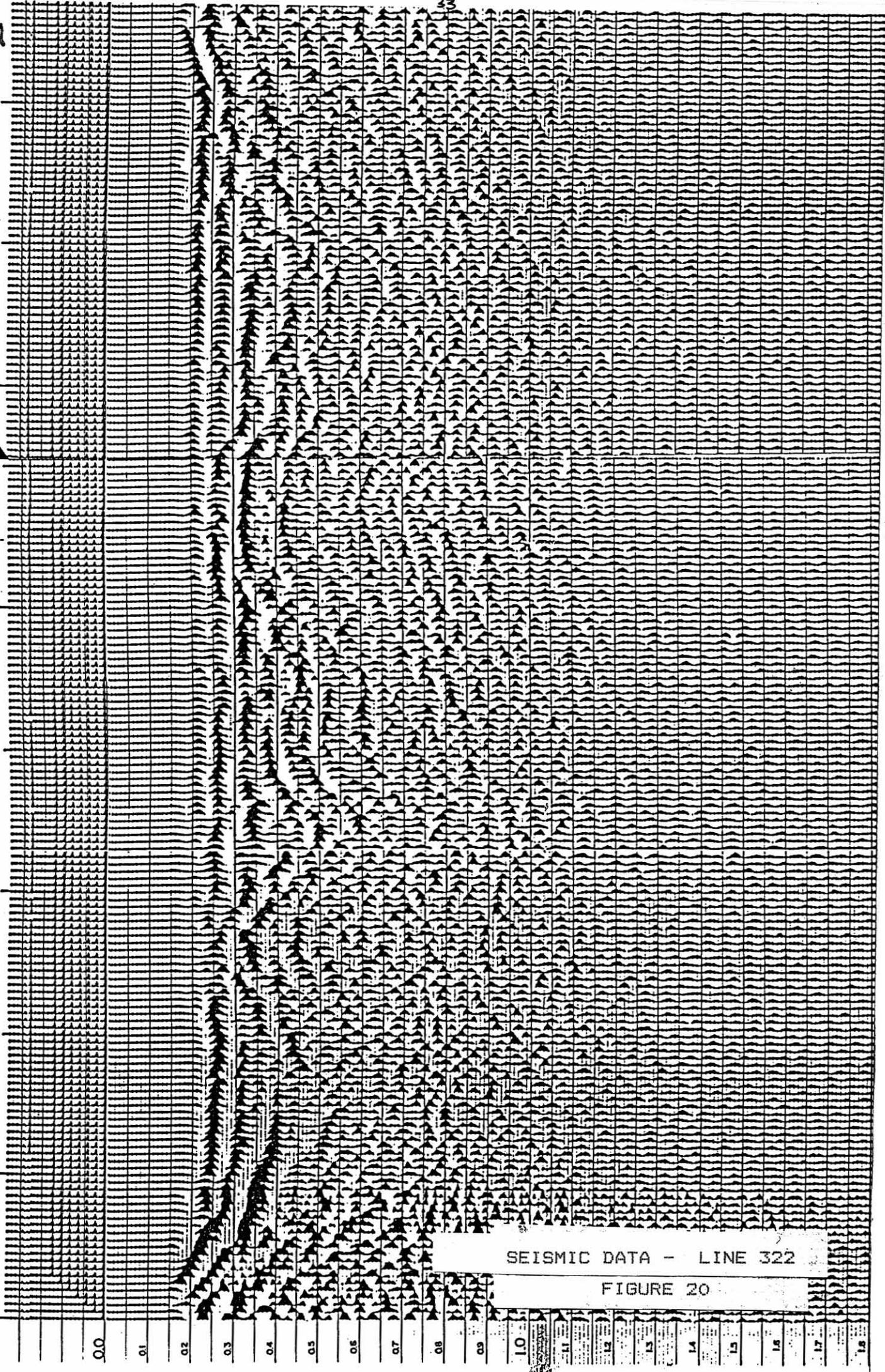
Tasman Head

TW334

Scale: Derived by 1:50,000. Points plotted from 1:50,000 to 1:25,000.

CVT 1

097
258' 50
891098
246' 40
322
234' 30
222' 20
198' 10
198' 5



SEISMIC DATA - LINE 322

FIGURE 20

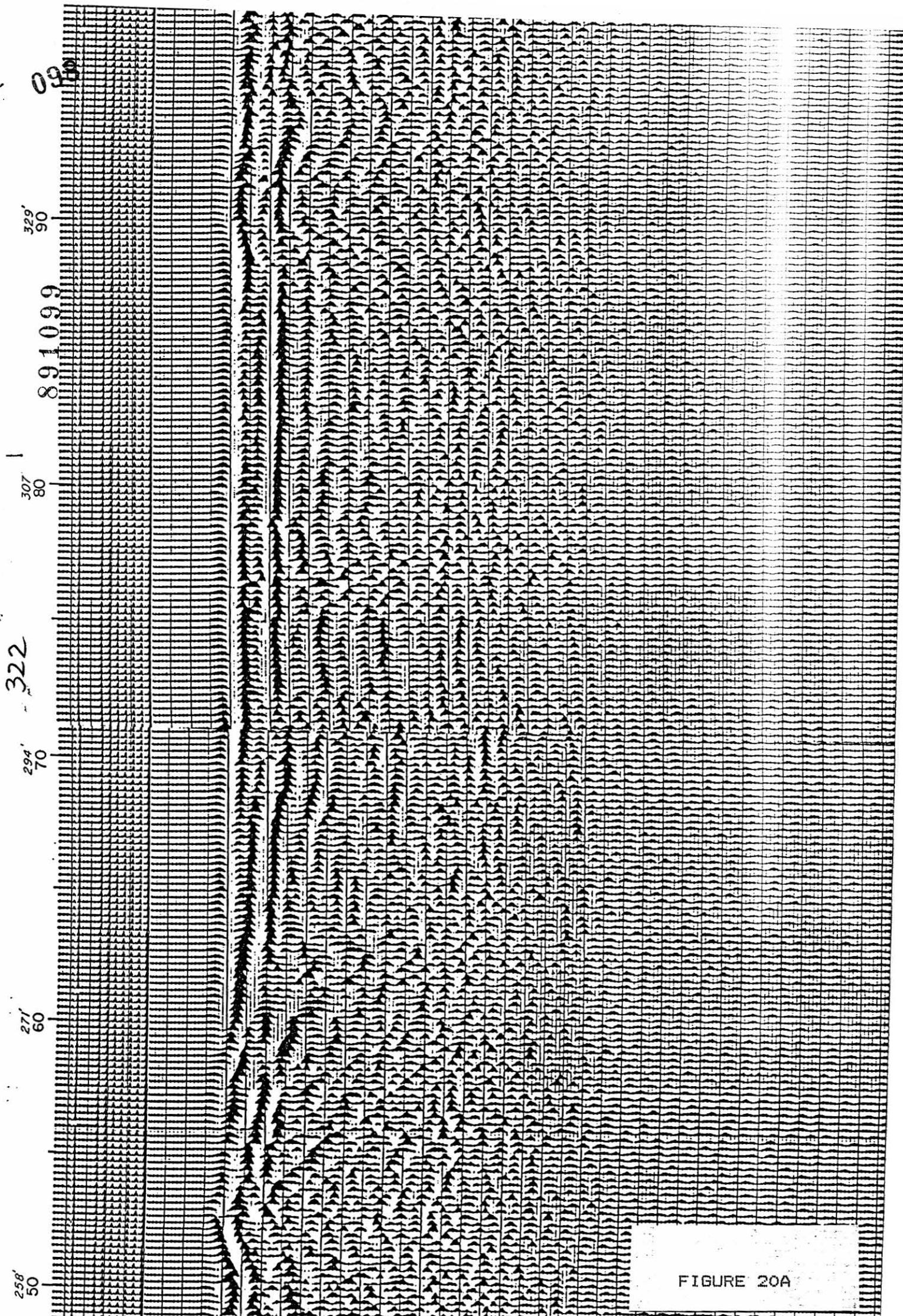
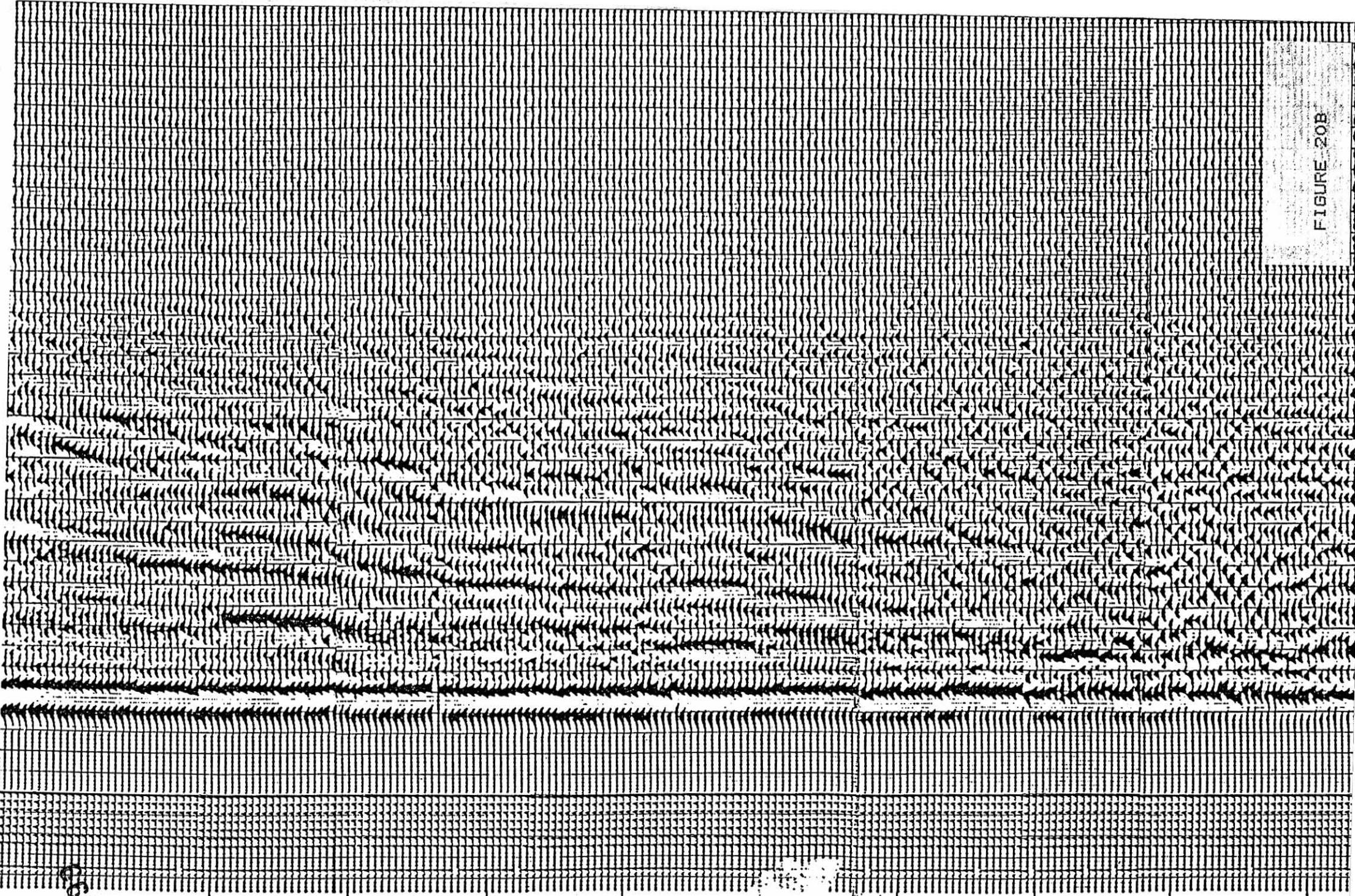


FIGURE 20A

FIGURE 20B



385
D10

378
130

891100

354
120

322

330
110

324
100



282
40

891101

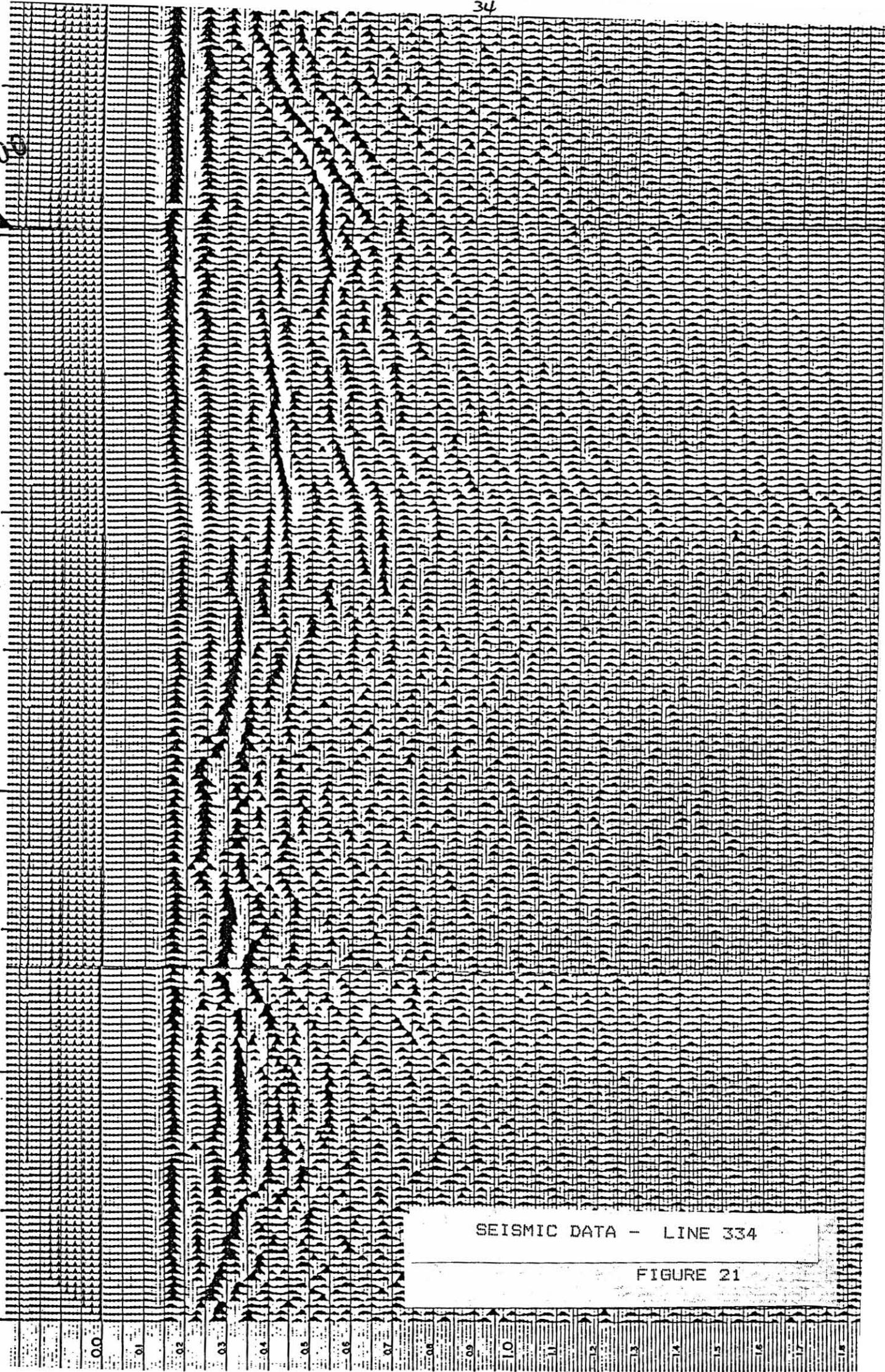
276
30

270
20

334

252
10

240



SEISMIC DATA - LINE 334

FIGURE 21

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8

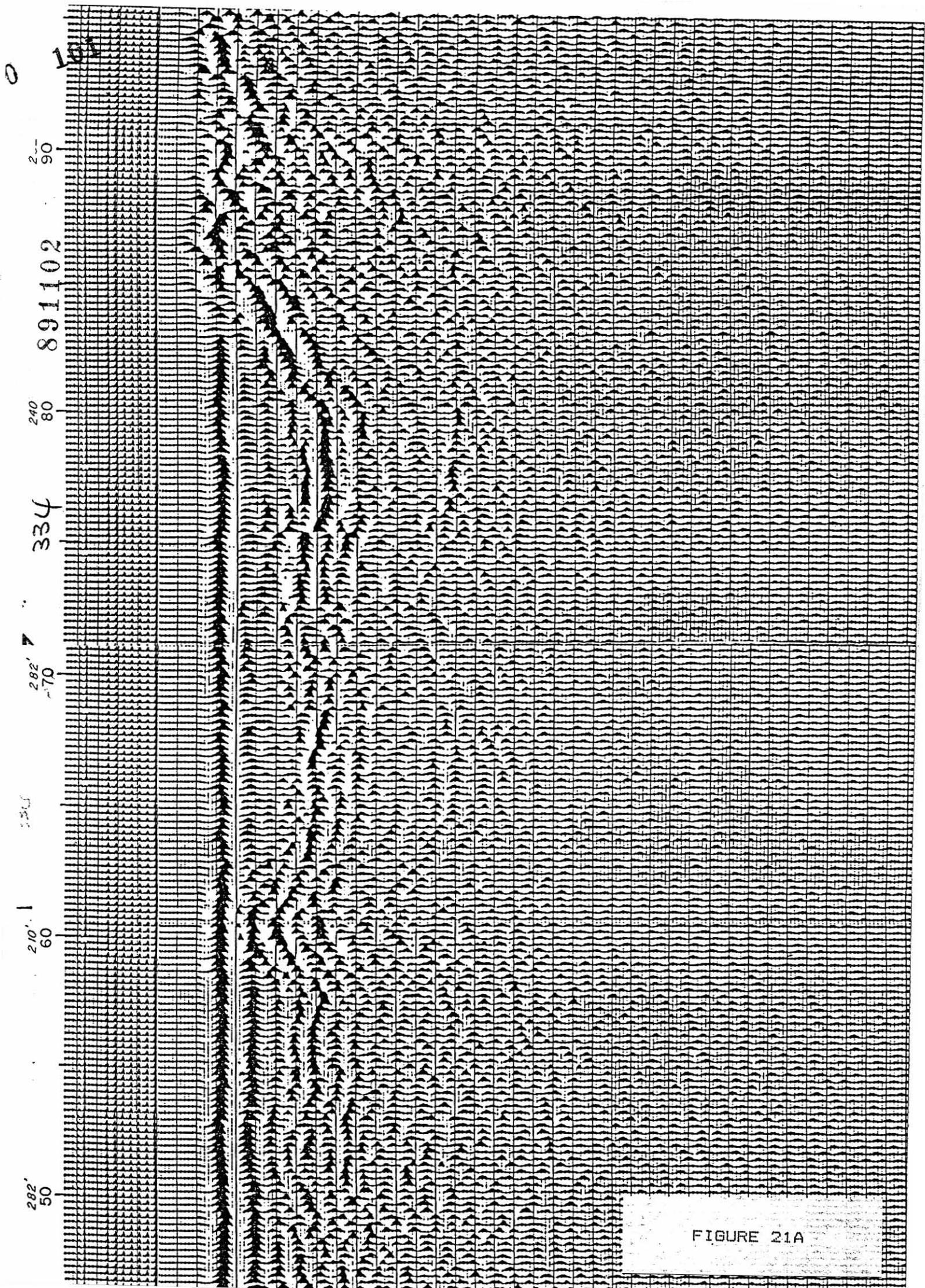
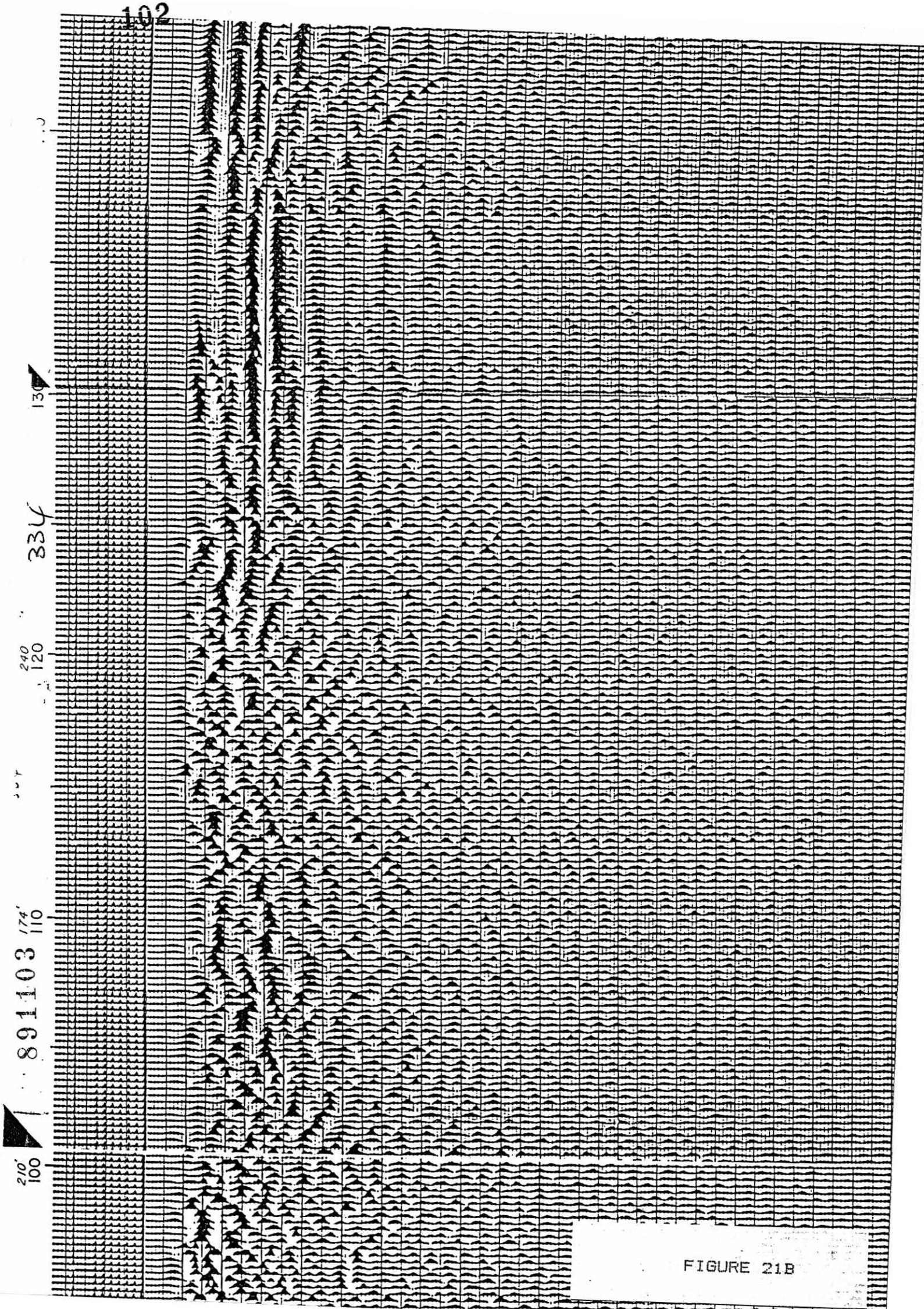


FIGURE 21A



210'
100'

891103 174'

240
120

334

130

102

FIGURE 21B

6' 90 103

264'
300

334

438'
310

891104

334

480'
320

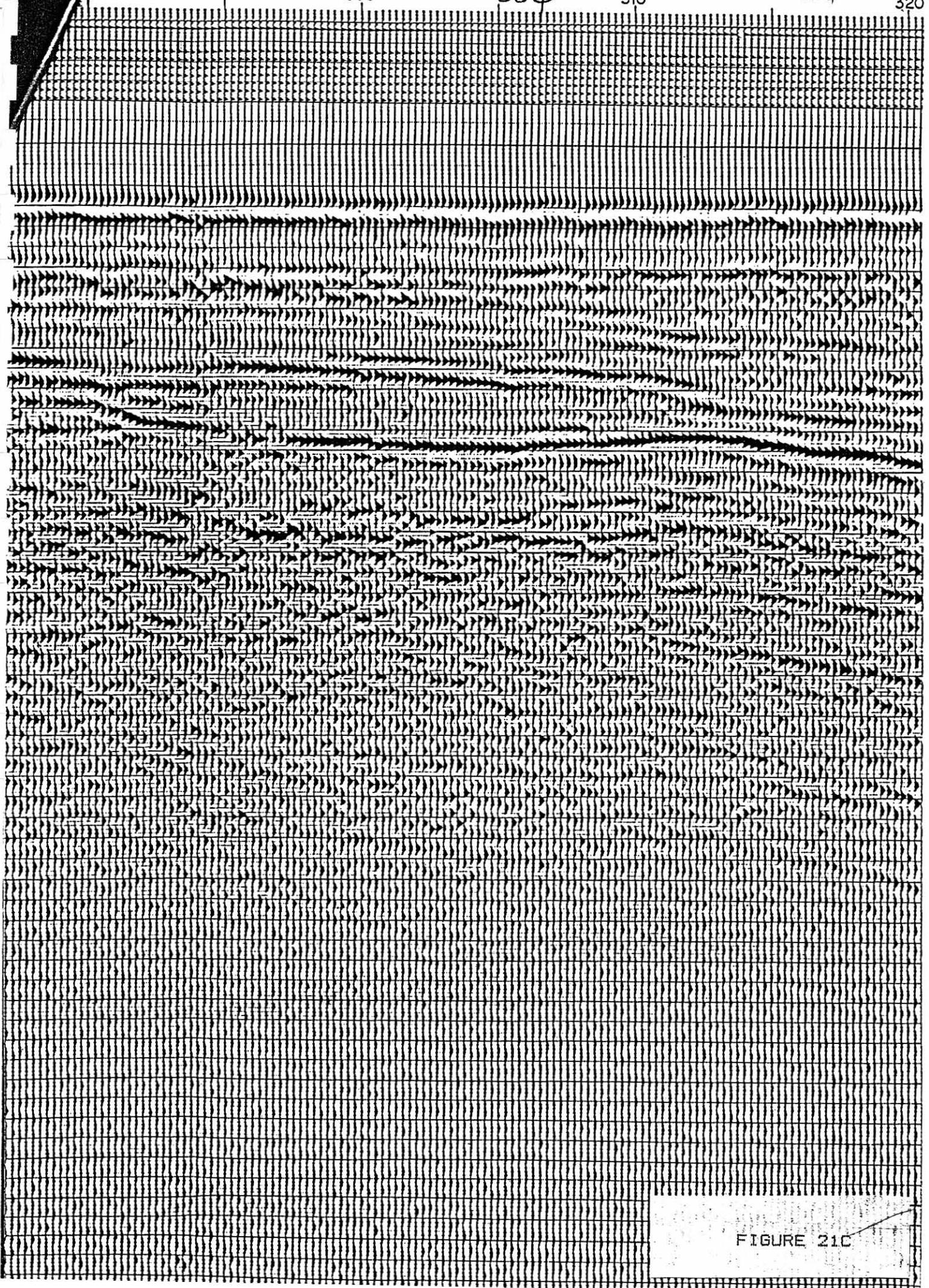


FIGURE 21C

THERMAL DATA

Relatively high temperature gradients and heat flows have been measured in Tasmania. The average heat flow has been estimated at more than 80-90 mW/sq m (Cull, 1982). A value of 87 mW/sq m was obtained in the borehole at Glenorchy.

Thermal springs are relatively uncommon which probably reflects, encouragingly, poor fluid circulation rather than absence of increased temperatures at shallow depth. This view is consistent with much of the dolerite-intruded Permian section acting as an effective seal. The thermal springs at Hastings occur near the margin of this section in a zone which is faulted. Even so the temperatures do not imply a circulation from depths in excess of 1000 m.

The data available suggest higher heat flows are related to old geosynclines or granitic rather than metamorphic basement. This is supported by the presence of Cambrian rocks beneath parts of this area - or at least the region immediately north of it (see interpretation below).

INTERPRETATION

The limitations in the data available have greatly restricted interpretation possibilities at this stage. Figure 4 shows that the magnetic coverage is patchy and non-existent where most critical - across the exploration licences. As discussed above there is also an array of doubts and uncertainties concerning its specification and the maps and profiles cannot be reproduced from actual observations (with the exception of the Marathon data). Regional interpretation using this data is virtually impossible. The only linking and grossly regional data is provided by the high level BMR profiles. Although these also carry potential problems calculation has shown that the features evident are approximately reproducible from all other data sets, given reasonable assumptions concerning specification or acceptance of claimed specifications. The following interpretation is based on the two profiles which transect the study area - lines 5200 000 mN and 5220 000 mN. In order to limit the inevitable ambiguities inherent in the interpretation of widely separated lines and the approximations introduced by simple interpretive assumptions gravity profiles were constructed from my 2 km average sampling of the data base at these northings. The gravity profiles are not to be taken as literal fact since there are many interpolated values and quite large gaps in data - issues not evident in the plotted profiles. The integrative capacity of the gravity field and interpretive methods does disguise this somewhat at the scale of study used here.

The combined gravity -magnetic interpretation provided here is weakened by all these deficiencies.

The discussion is based on rudimentary methods and the approach was designed simply to determine whether, or what, structural features can be resolved with moderate survey specification. Only simple model concepts have been used at this stage in order to satisfy these objectives and suggest future requirements or potential. The crude models presented in the Figures have been selected from a number of variants tested and are intended to indicate what can be done and what issues are crucial to structural resolution.

Consider line 5200 000 mN. From 470-560 000 mE. Northing of Strathblane-Lunawanna.

The inferred, observed Bouguer gravity profile (at density 2.67 t/cu m) is shown in Figures 22 and 23. The profile contains a number of poorly defined segments but shows generally increasing values from west to east. The gradient is strongest in the region immediately east of the Picton River. This is a characteristic pattern in Tasmania and shown by Leaman (1986) to represent a thick Lower Palaeozoic sequence dominated by Cambrian units. Densities have been referred to a reference value of 2.67 t/cu m as applied to the Precambrian

geanticline rocks at the western end of the profile. This value is approximately valid but may be in error by up to -0.04 t/cu m. Other values could be raised by up to this amount. The absolute values are not critical to this discussion since sizeable contrasts are in evidence. Two possible solutions are shown. A slab of Permian rocks containing a single dolerite sheet is included in each. The Permian-dolerite structures are much more complex than this but the smoothing of both gravity and magnetic data means that inclusion of such detail is pointless. In option 1 (Figure 22) the denser Cambrian section thickens rapidly eastward from a point east of Adamsons Peak. It should be noted here that Cambrian rocks generally possess densities in excess of 2.74 t/cu m and only the limestones of the Gordon Group, among all other Palaeozoic rocks, can match this density. The limestones, however, cannot solely source this anomaly since the thickness of section implied is in excess of 5 km. They clearly overlap these rocks, however, as shown by exposures in the Picton River. Option 1 also shows that the Cambro-Ordovician section cannot thicken indefinitely to the east. A solution proffered in option 1 is that of a thicker post Ordovician section. Up to 5 km is implied.

This solution can be contrasted with that in option 2 (Figure 23). The basic elements of the solution cannot be changed but a much more structured arrangement for the Palaeozoic section is implied. This is much more consistent and geologically believable as presented but option 1 could be more realistically shaped within the present data. The solution in option 2 should be adjusted to thin the deeper section within the anticline at about $510\ 000$ mE. This presumes that the form of the profile is valid and such refinements do depend on better data.

Negative effects in each of Figures 22 and 23 reflect Tertiary deposits within Adventure Bay and well into Storm Bay. The large positive effect so evident in Figures 17 and 18 within Storm Bay is clearly related to a very thick section of Cambrian rocks.

The crude gravimetric models show that the Lower Palaeozoic section is folded with wavelengths of no more than 16 km and that the synclines, at least, have preserved most of the section - including Siluro-Devonian rocks. The Cambrian section is dominant and may exceed 7 km in thickness. Cambrian and Ordovician rocks onlap Precambrian basement in the region of Adamsons Peak. Irregularities in the profiles may be due to interpretable dolerite effects but an attempt to do this is beyond this review and, almost certainly, amounts to over-interpretation of this data.

The magnetic profile is shown in Figure 24. The essential elements of the gravity view are supported. A more rigorous form for the Cambrian rocks is suggested. It should be noted that only the Tertiary basalts, Jurassic dolerite and large parts of the Cambrian sequence are significantly magnetic. The basalts are insignificant in this region and the dolerite has been omitted from this model since it contributes relatively

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small amounts to the anomalies at this level. The primary anomaly source is shown - the Cambrian - and it defines the first order structuring in the target rocks. Dolerite effects are almost certainly present, e.g., the sharp feature east of Fluted Cape, but the broad swell of anomaly upon which it rises is due to the material at depth. Similarly the large peak in the region east of Adamsons Peak, shown in Figure 14 to be the reduced response of all the low level anomalies, is due largely to the margin of the Cambrian trough with dolerite effects superimposed. It is clear that data at 3000 m can still resolve some dolerite structure. The peak anomaly is inferred to indicate a more magnetic unit within the lower part of the Cambrian section and this is consistent with the presence of a correlate of the basalt-rich Mainwaring Group as in Western Tasmania.

The gravity and magnetic profiles are only significantly discordant at the eastern end of the profiles at this level of interpretation. I have inferred this to mean that the post Cambrian section thickens across Storm Bay. There is an alternative. The extension of the Tamar Lineament which bisects the basement rocks of Tasmania probably lies close to Cape Raoul. To the east lithologies observed in Northeast Tasmania are to be expected. If these are locally dominated by Mathinna Beds then the density picture suggested in Figure 23 could be maintained and the loss of magnetic contrast would cause the magnetic field values to roll over as in Figure 24. Resolution of this issue is not critical to this review but these notes do suggest the potential of these methods to solve issues of basement geology.

Line 5220 000 mN. From 470-560 000 mE. At the approx
northing of Cygnet-Woodbridge.

This profile is unusual in that it carries some deep control and the magnetics are exceptional.

The principal elements of the gravity profile (Figure 25) are as described for the Dover line. The negative anomaly in Storm Bay is larger indicating up to 1000 m of Tertiary sediment. The increase in the gravity field eastward again reflects the approach of the continental margin and the increased thickness of Cambrian rocks. This solution is valid as far east as Cygnet. But at Woodbridge drilling encountered Precambrian schists beneath the Permian cover. This is crucial information. The gravity profile, inadequate though it is, shows beyond any shadow of doubt that these Precambrian rocks do not constitute part of any significant basement block. Were this to be so, with units onlapping from the west - at least, then the reduction observed in the gravity field would be comparable with the gradients noted west of Geveston. The direct implication is, as was found in western Tasmania by Leaman (1986), that the entire eastern end of the section is overthrust.

It must be admitted that this is only one solution to the gravity problem and the occurrence of shallow Precambrian

C. 108

basement. Another solution is suggested by the model options discussed for line 5200 000 mN. It is possible that the anticlinal structures inferred near 510 000 mE (Figures 23 and 24) plunge steeply southward. The effect of this would be to transfer the Precambrian from a position beneath the Permian at Woodbridge but perhaps 5 km deeper at Lunawanna. This structural option is resolvable using three dimensional methods but not with the present data. It is an important consideration since it could imply a lengthy source to reservoir path from the south and the crest of the structure would need careful definition prior to drilling. It would also be important to infer the location of the zone in which the Palaeozoic rocks onlap the Precambrian basement but are still present as a wedge beneath the Permian, presumed, seal. If this structure is the actual case then drilling near the present seeps would be wasteful and uninformative.

The magnetic profile (Figure 26) essentially supports the gravity implication. Some minor dolerite effects are evident in the Bruny region but the anomaly west of Geeveston reflects the edge of Cambrian deposition with its basalt-rich basal members. The very large anomaly centred on Cygnet is unique within this survey. Various possibilities were attempted for its solution but the most likely is shown; a laccolith of Cretaceous syenite. Such a body would lead to the observed doming. The correlation with syenites is certain but more data (lines) are required to establish the overall forms and relationships between the distribution of the syenites and other structures.

The models presented for the two available profiles are not final or absolute solutions. They serve to show some of the structures, and a coarse indication of the resolution, possible. Not all options were shown for each line. Thus a thrust solution was possible for the southern line. Various structural styles have been indicated, fold systems, thrusts, intrusions etc, but use of more refined techniques are required to generate more detailed and less ambiguous results. These can not be justified with the present data.

The gravity and magnetic data available have been compared with geological base mapping. Fracture and fault trends have been plotted and compared with the more obvious lineaments in the geophysical data (Figure 27). This has been done on the presumption that many basement structures will have been repeatedly rejuvenated and some expression may impress through the post Permian cover. Some interesting alignments and offsets are suggested. The extent of Cretaceous activity may be greater than thought and ENE structuring may be significant. The contrast between the Jurassic-Tertiary faulted region east of North Bruny and the remainder of the region is striking.

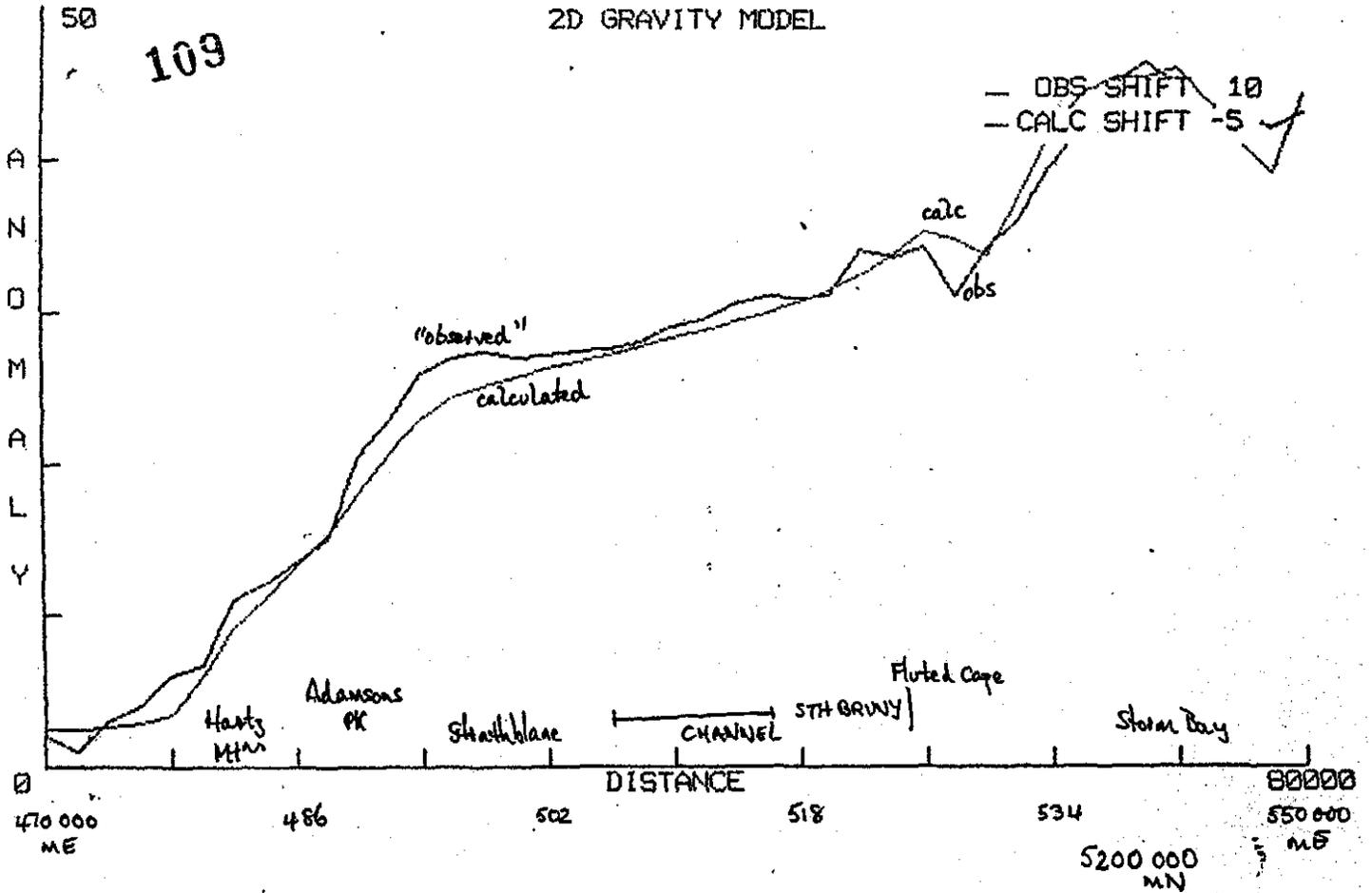
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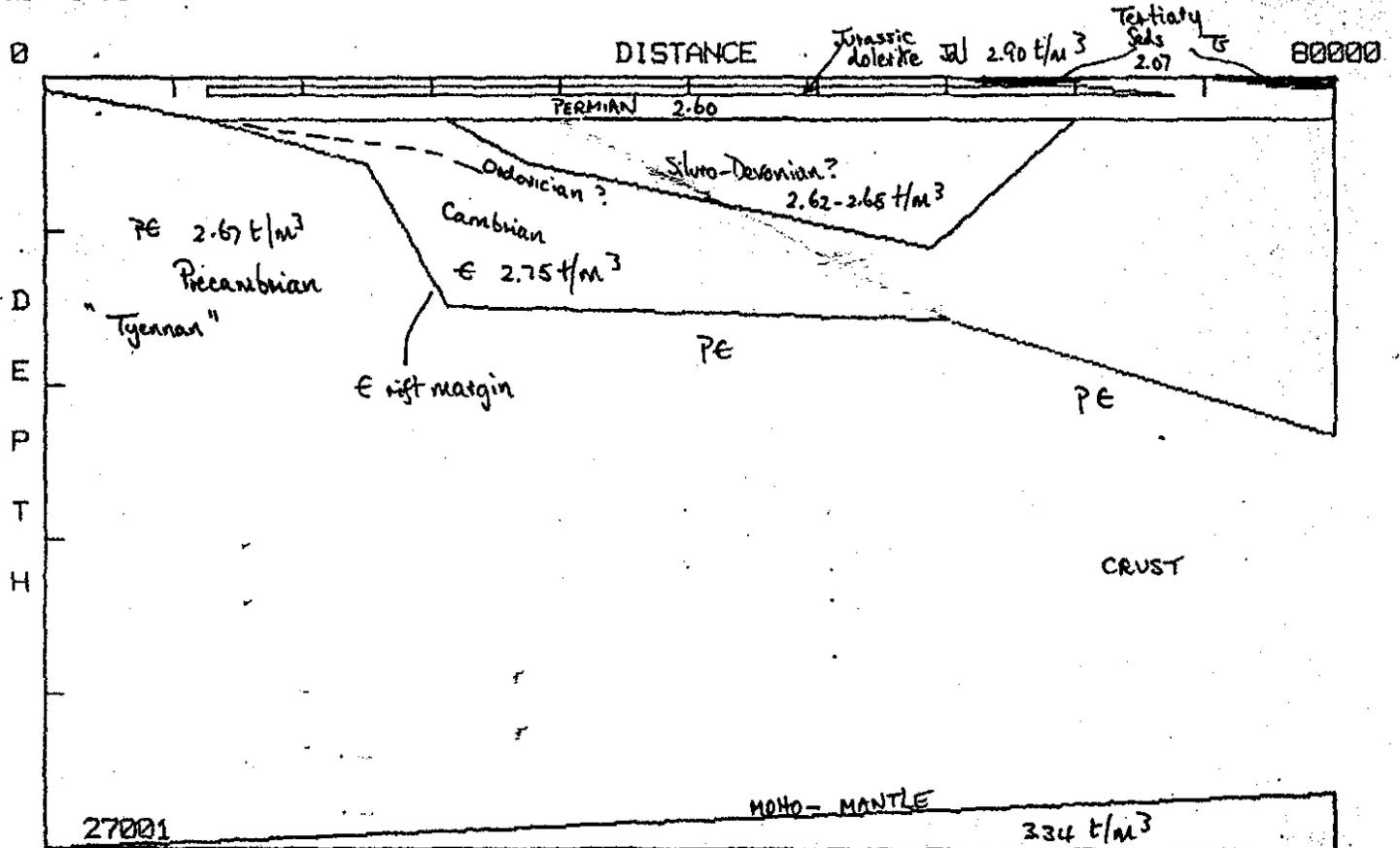
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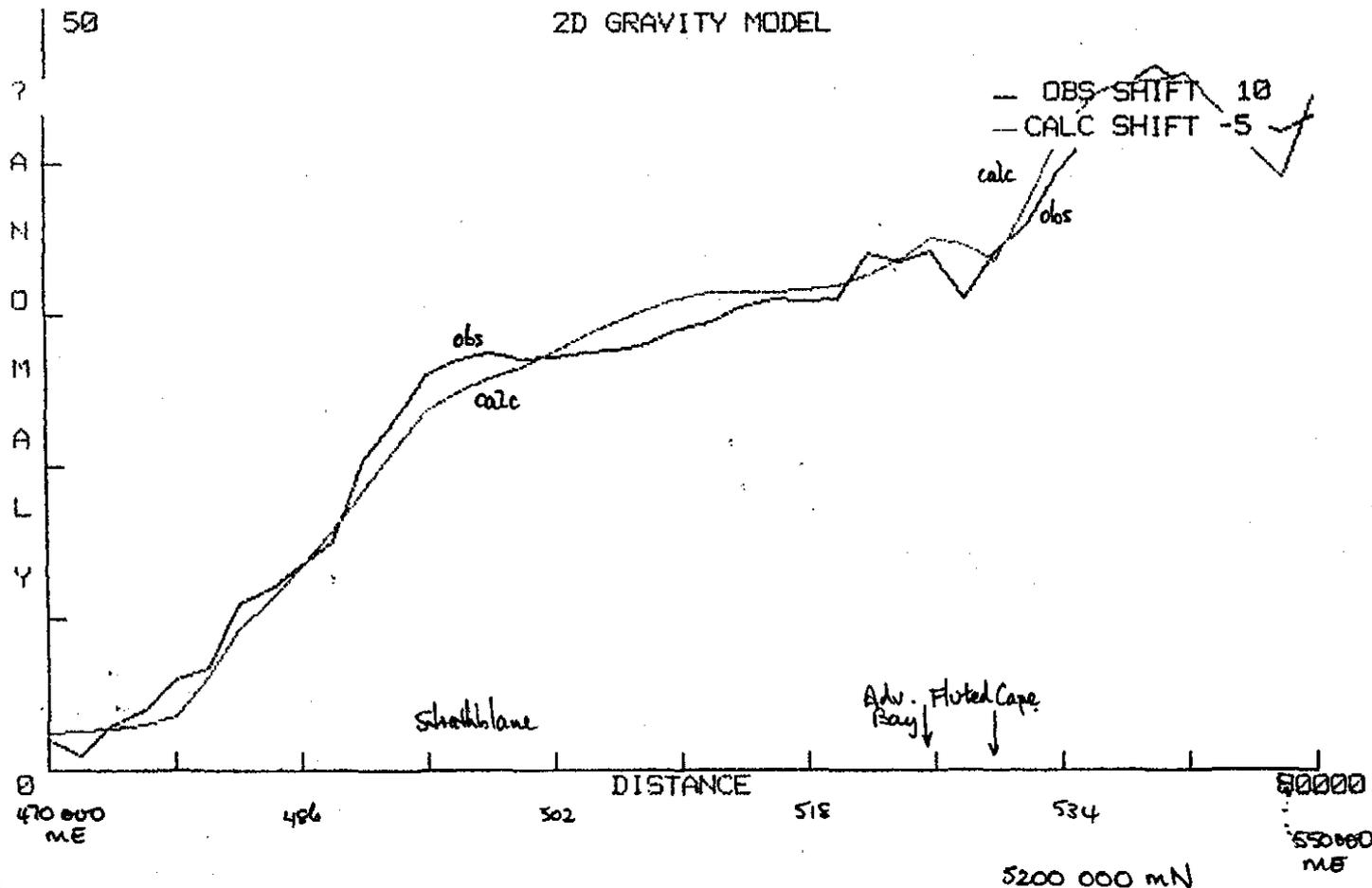


REGIONAL PROFILE DOVER-STH BRUNY 470-550E
 ADJ 1 11

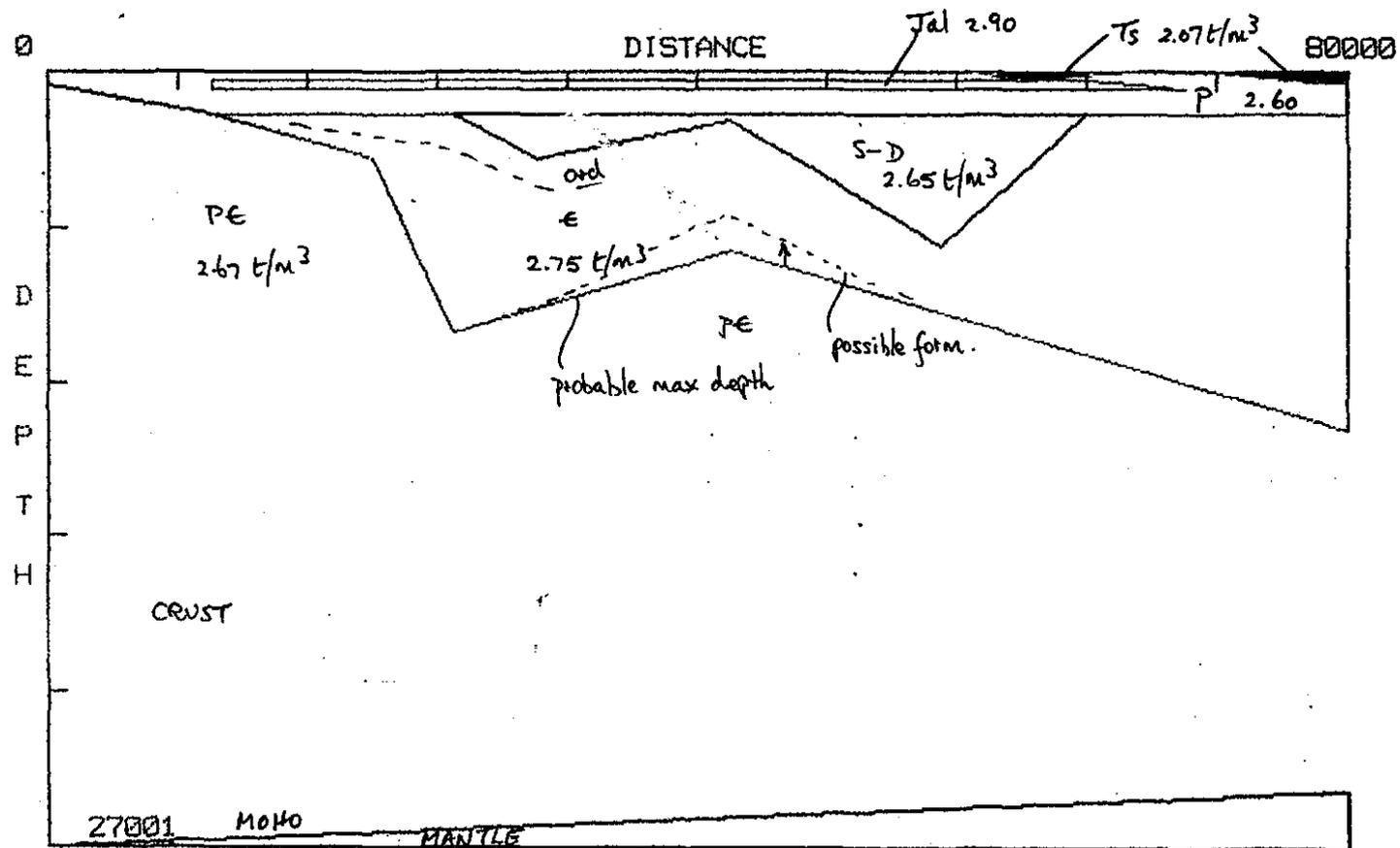


GRAVITY INTERPRETATION (option 1) - LINE 5200 000 MN

41



REGIONAL PROFILE DOVER-STH BRUNY 470-550E
MOD2 ADJ 2 3 11 TO ANTICLINE NOT SYNCLINE



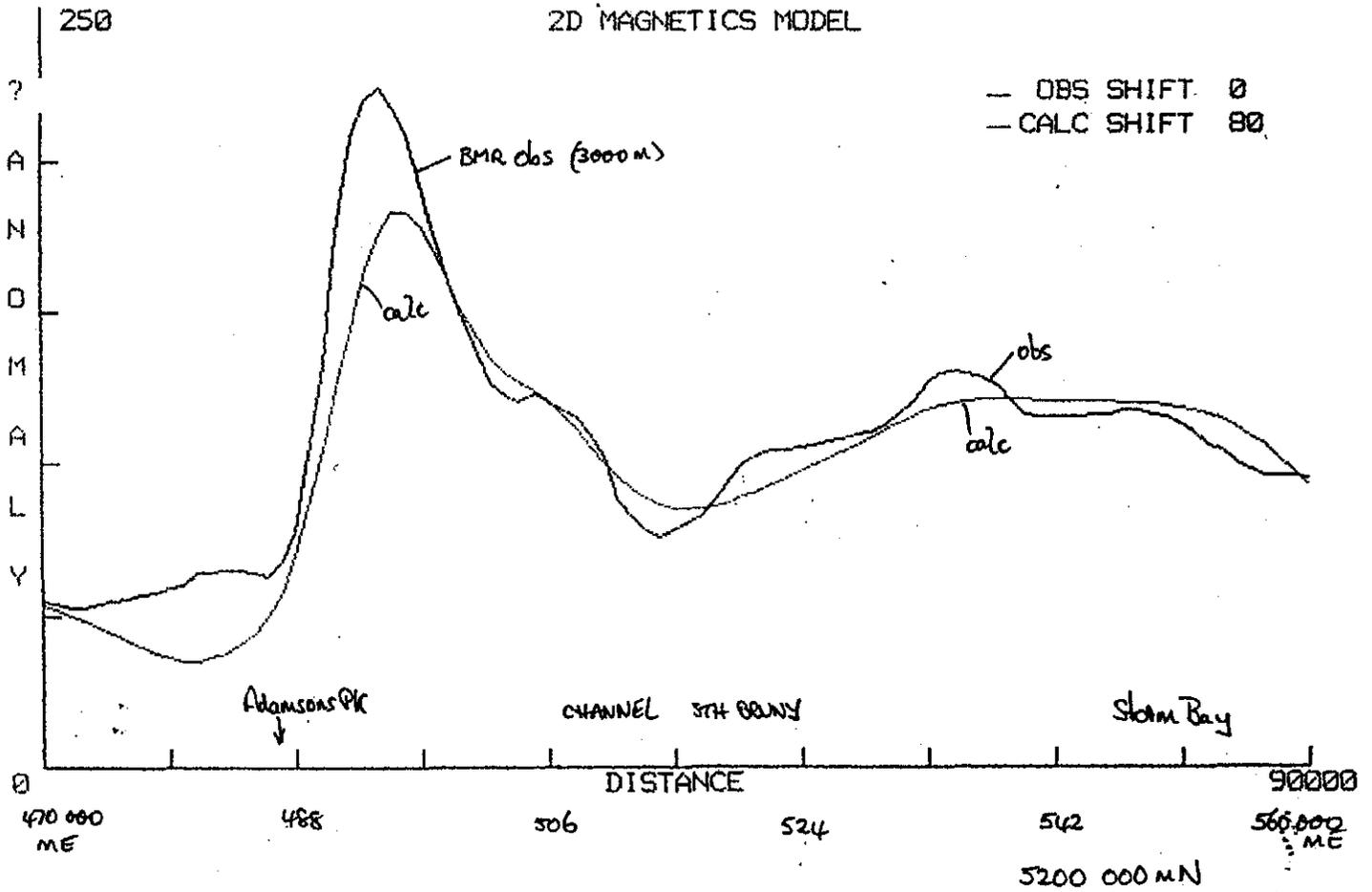
GRAVITY INTERPRETATION (option 2) - LINE 5200 000 mN

LEAMAN GEOPHYSICS

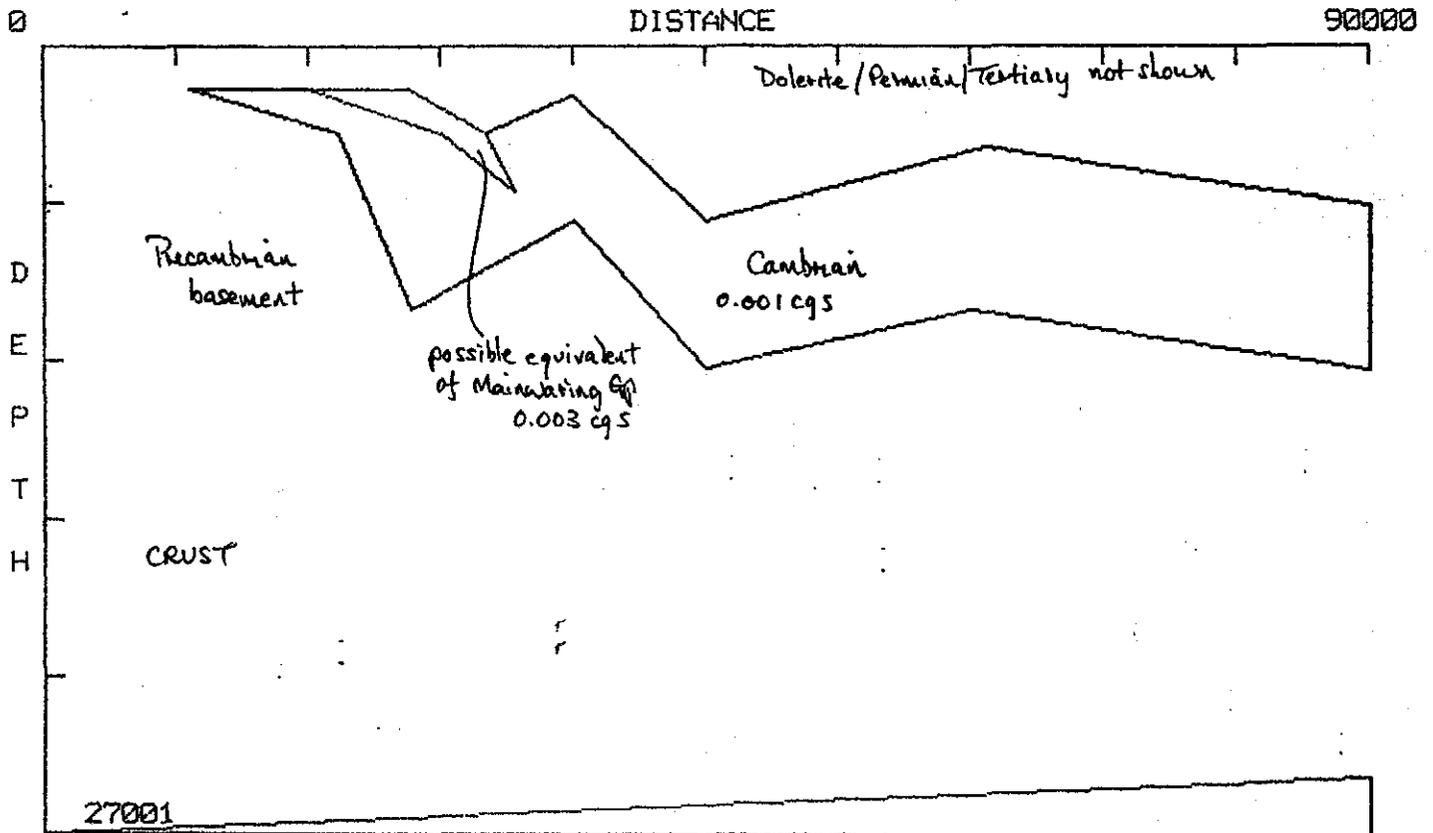
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REGIONAL PROFILE DOVER-STH BRUNY 470-560E



MAGNETIC INTERPRETATION

— LINE 5200 000 mN

FIGURE 24

LEAMAN GEOPHYSICS

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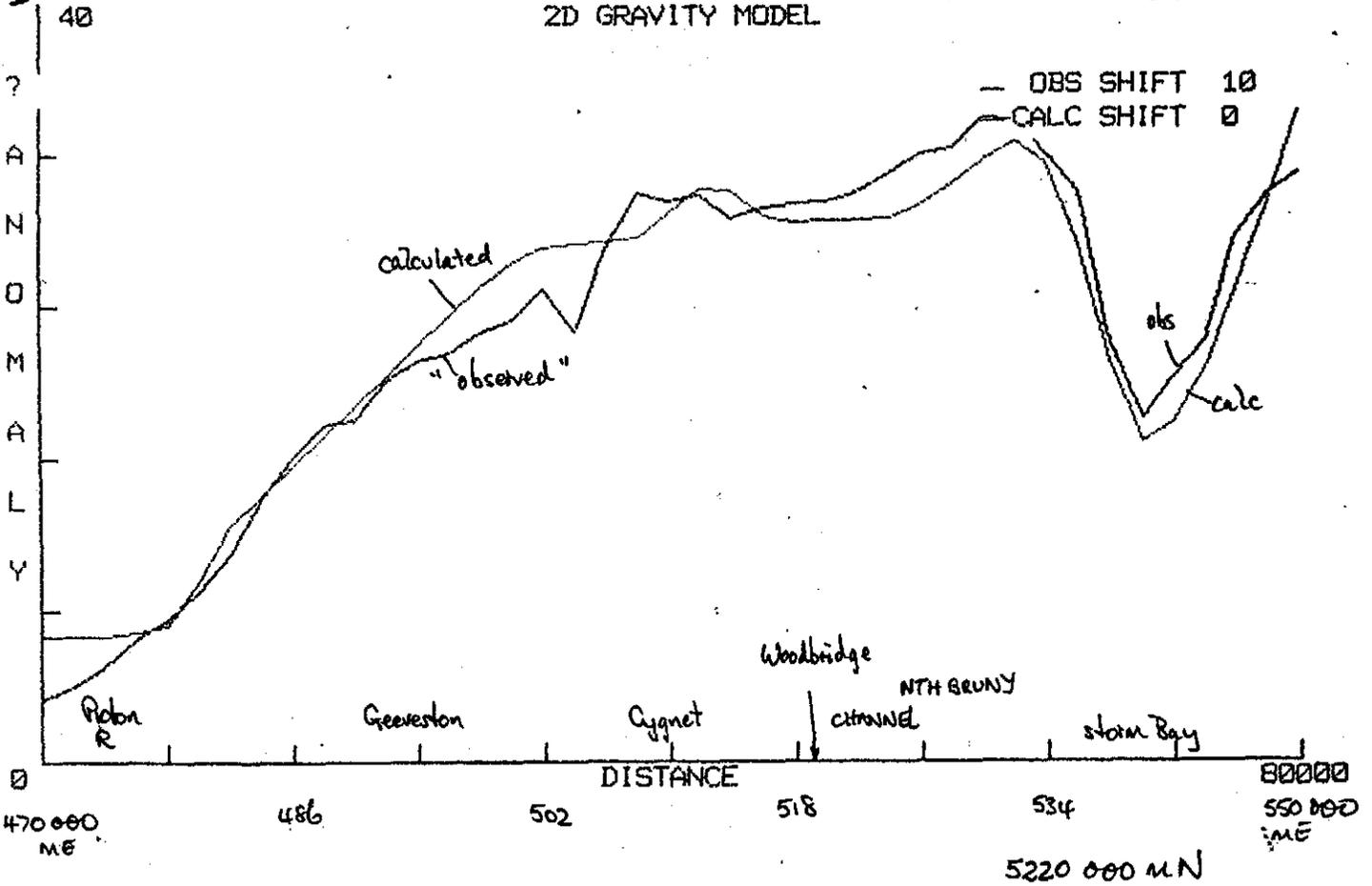
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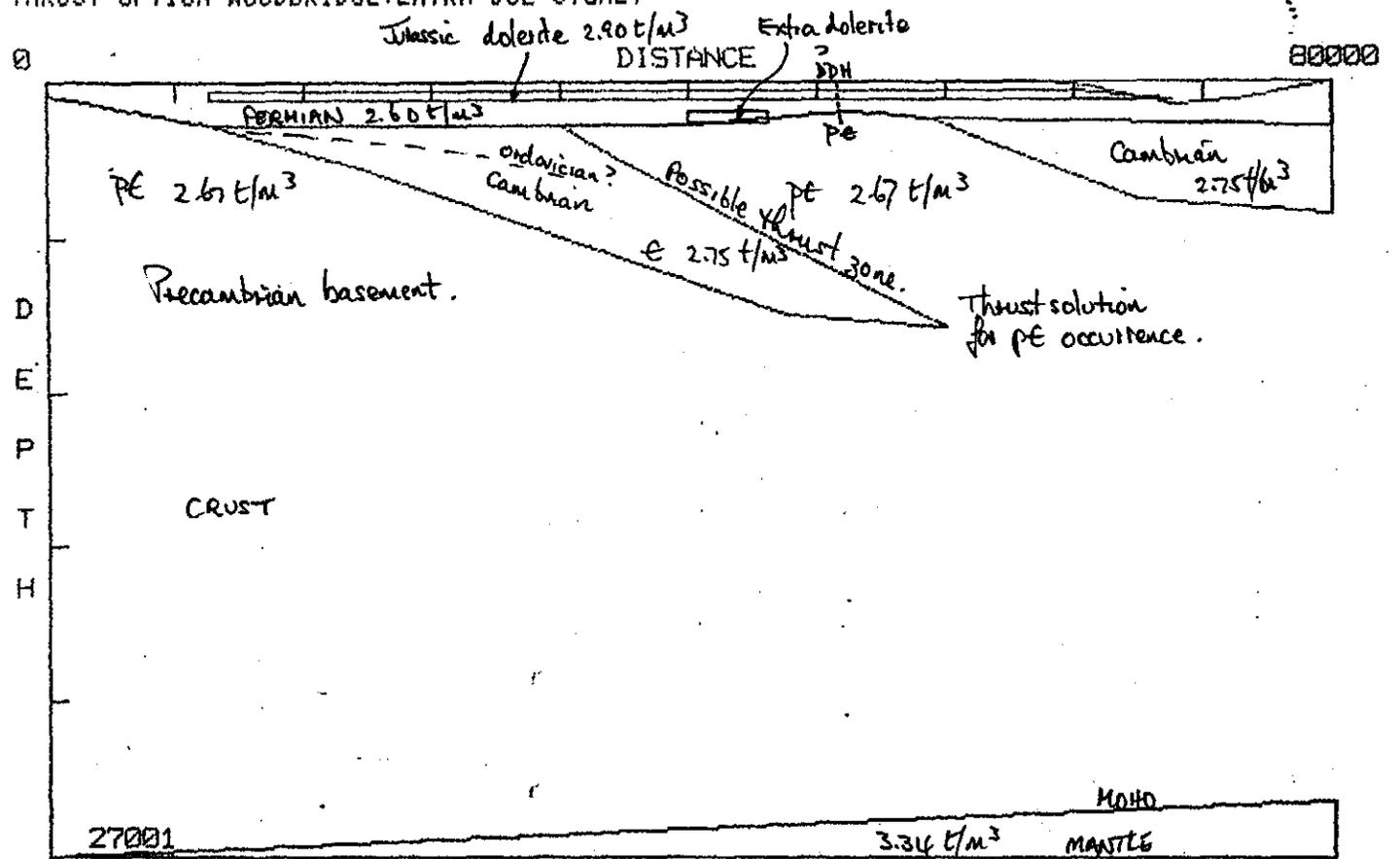
112

891113

2D GRAVITY MODEL



REGIONAL PROFILE CYGNET-NTH BRUNY 470-550E
THRUST OPTION WOODBRIDGE+EXTRA DOL CYGNET



GRAVITY INTERPRETATION

LINE 5220 000 mN

FIGURE 25

LEAMAN GEOPHYSICS

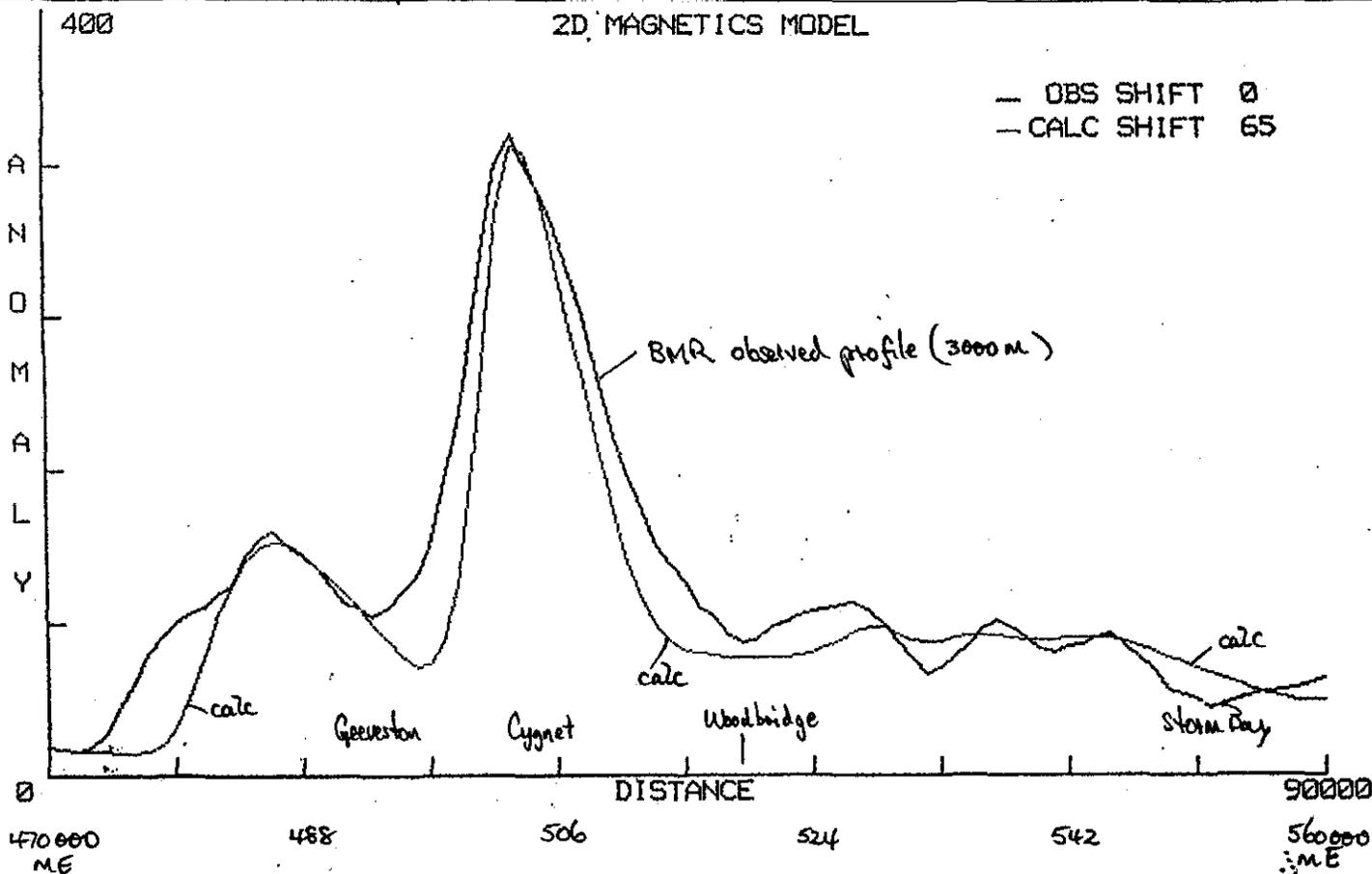
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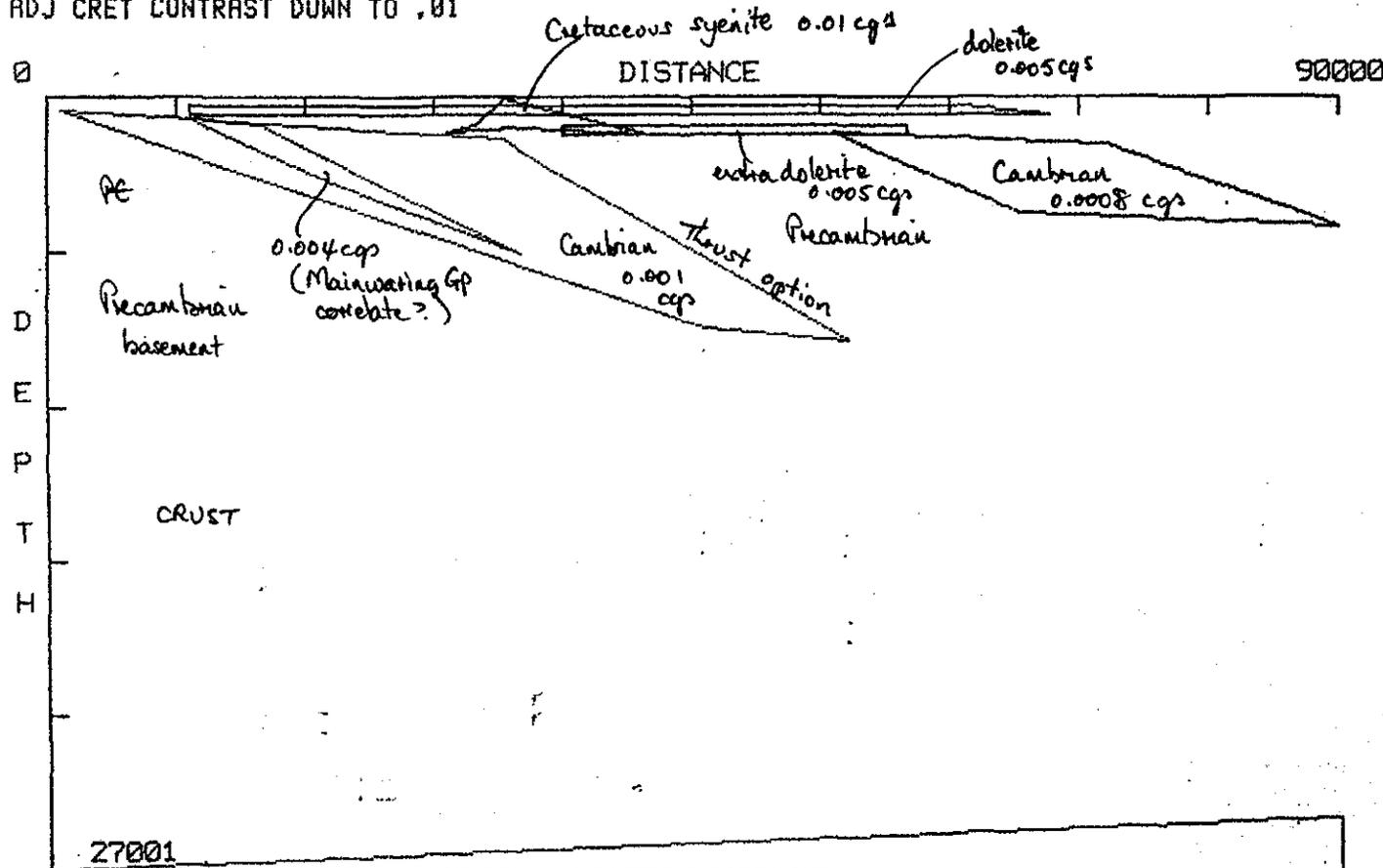
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891114



REGIONAL PROFILE CYGNET-NTH BRUNY 470-560E
ADJ CRET CONTRAST DOWN TO .01



MAGNETIC INTERPRETATION

LINE 5220 000 mN

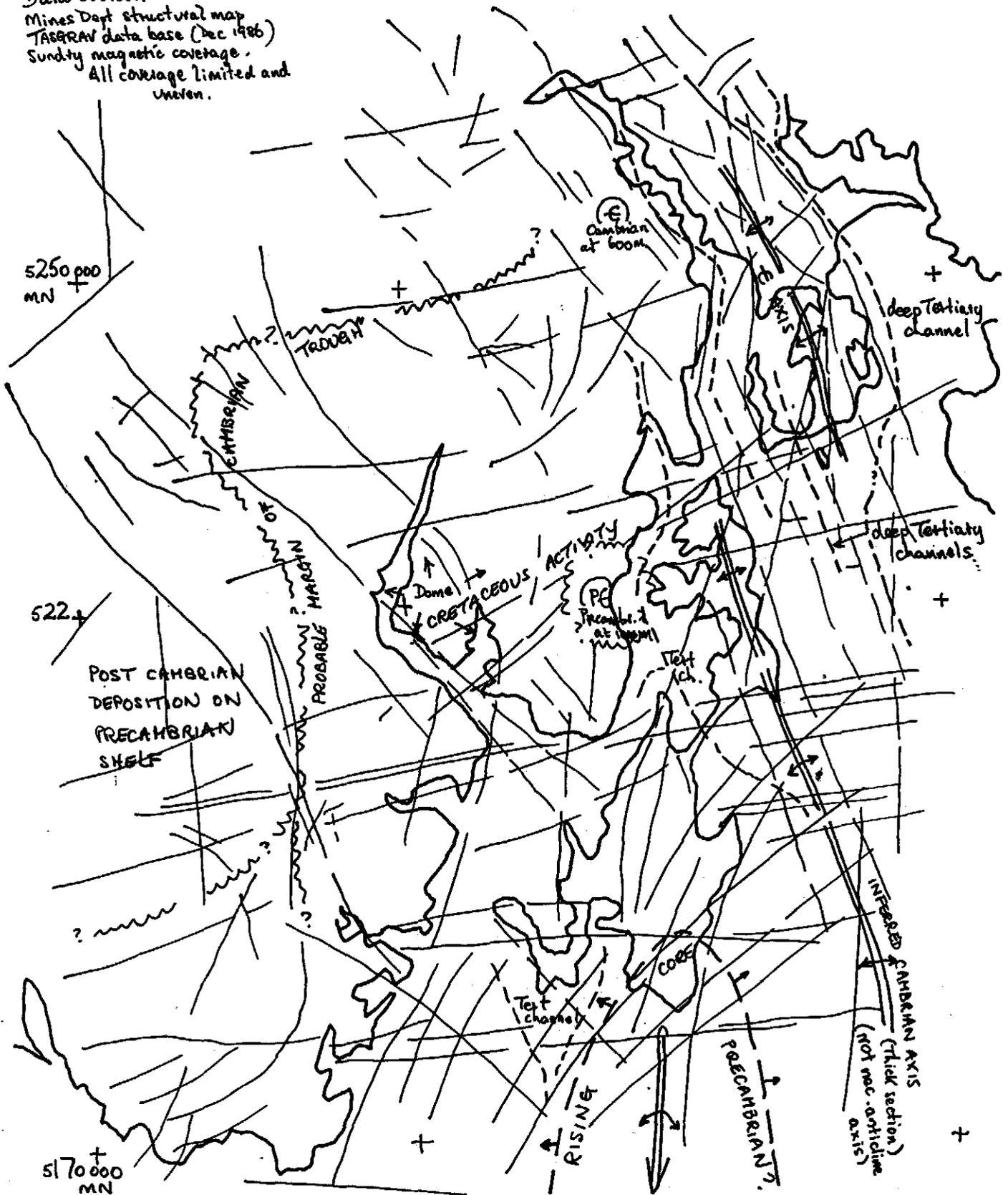
FIGURE 26

470 000 ME
+

500
+

550000 ME
+

Data sources:
Mines Dept structural map
TASGRAN data base (Dec 1986)
Sundry magnetic coverage.
All coverage limited and
uneven.



5250 000 MN
+

522+

POST CAMBRIAN
DEPOSITION ON
PRECAMBRIAN
SHELF

5170 000 MN
+

TRENDS INFERRED FROM AVAILABLE GEOLOGICAL AND GEOPHYSICAL DATA
(No quantitative analysis; subjective interpolations)

CONCLUSIONS

The seismic, gravity and magnetic data inspected within the D'Entrecasteaux Channel region of southern Tasmania are variable in quality and very patchy in coverage.

There is no doubt that gravity and magnetic data, in tandem, can resolve many of the structural issues which are clearly relevant to exploration in this area - especially at levels beneath the Permo-Triassic cover. It is not claimed that these methods will resolve structures in sufficient detail to permit prospect analysis or precise well siting but they may be able to do so given adequate data bases and three dimensional interpretation methods. The available seismic data are not encouraging but technological advance in the past 15 years is expected to have overcome the obvious problems in the existing data. High source energies will be essential.

It appears that magnetic data are able to resolve some of the issues related to the form and distribution of the Cretaceous igneous rocks. Any patterns to these materials may well assist appraisal of thermal anomalies which might have assisted generation of hydrocarbons. Both gravity and magnetic data can resolve dolerite structures but it is probably best to use gravity data for primary analysis and check the results magnetically. Examination of Cretaceous or Jurassic intrusions does demand relatively detailed data coverages.

Both methods are able to define basement structures - particularly those involving the Cambrian sequences. Fortunately post Cambrian formations were deformed in parallel and so any definition of Cambrian forms enables assessment of younger rocks. This analysis coupled with depth analysis should allow estimation of sections or wedges beneath the Permian cover.

A comprehensive gravity-magnetic coverage and analysis is justified and certain to be a very cost effective means of providing a basic description of the two key exploration issues; namely where are the source rocks and where are the likely structural closures. Well location definition may still require limited seismic coverage and some random seismic coverage is advised early in the programme to support the more regional analysis.

The area covered by new gravity and magnetic surveys must be much larger than that covered by the licence areas. This is essential to provision of relatively unambiguous detailed interpretation. Unless the data base is improved beyond the area of immediate interest then many anomalies and interpretations cannot be anchored (structures traced from exposure or other control) and no amount of detail within the target area can recover this loss.

RECOMMENDATIONS

The thrust of the following recommendations was alluded to in the conclusions given above. A comprehensive magnetic coverage is essential and the existing gravity data base must be filled in. This is necessary in order to provide sufficient detail and certainty and allow evaluation of both near surface structures (esp. dolerite) and finer resolution of deep structure.

The fundamental problem relates to decisions about specifications. Geological issues range from very shallow to quite deep in this area and this poses awkward decisions concerning any proposed surveys.

In the MAGNETIC case, for example, it is possible to fly low using a mean terrain clearance of 100 or 150 m and obtain detailed results. This may require difficult and more expensive flying but the results can always be adjusted, at some expense, to any other level. There is no loss in resolution at any stage. Alternatively the survey could be flown at a fixed level of 1000 m. This makes for a cheaper, safer survey but means that the fine detail observed by low flying can never be recovered. The calculations undertaken in this review show that useful structural interpretation is still possible using data collected as high as 3000 m where the problems examined are generally of this order of depth. Some fine detail related to large near surface intrusions is still retained. A reasonable compromise would seem to be an elevation of 600-1250 m based on the continuation studies. At 1000 m high points such as Adamsons Peak are readily avoided and only the crest of the Hartz Mountains provides any barrier.

The GRAVITY situation is not as simply resolved since a large scale detailed coverage of a large part of the state cannot be justified. A reasonable compromise is provision of a nominal station spacing of 2 to 3 km in gaps outside the immediate licence areas and 1 to 2 km inside. This will provide sufficient information to resolve most dolerite-related features within the licence areas while providing the essential regional definition for resolution of deeper issues. In most cases this will mean utilisation of road traverses but some time should be allocated to helicopter locations in the region west of EL 7/86 since other access is not feasible.

In each case, gravity and magnetics, it is suggested that the area covered (or brought up to required standard) be the 80 km square defined in Figures 1, 17 and 18. Magnetic data may be acquired across this entire area but gravity data will be land limited unless any ship engaged for seismic work is fitted with marine gravimeters. It is suggested that stations be observed on all islands within the Channel in order to optimise coverage. It is inevitable that the final

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gravity coverage will be somewhat uneven beyond the confines of the licence areas but this is not expected to generate difficulties due to acquisition of uniform whole area magnetic coverage.

Some reflection seismic coverage is essential in order to flesh out, geologically, the structures inferred from the magnetic and gravity data. Land seismic work is not recommended at an early stage in exploration of this region due to problems of cost, logistics, objections and terrain. It may be essential to final targetting but cannot be considered as a viable means of initial prospecting. Instead, I propose a few long traverses along the Channel and Huon estuary. Even this situation will not make for easy survey due to limits on manoevrability and water depth but the problems of objections and terrain are removed, costs are reduced and data quality improved. Given the present crude interpretation, and presuming that seismic work is undertaken prior to completion of new gravity-magnetic interpretations, traverse density should be greatest in Isthmus Bay and the region between Scott Point south of Dover and Roberts Point.

Summary of recommendations:

- Magnetics: Fly the area from 470-550000 mE and 5217-5250000 mN at an elevation of 1000 m. Avoid higher points and drape at 100 m where necessary (only Hartz Mts). Use a line spacing of 2.5 km. Tie line separation 5 to 10 km. Tie lines to be flown north-south and survey east-west. Total line km estimated at 3000 km. A high resolution magnetometer must be used.
- Gravity: 1. Upgrade coverage within licence area to ensure no station gap larger than 1.5 to 2 km. Observe stations on all islands.
2. Upgrade coverage outside licence area wherever possible to do so cheaply and rapidly. Aim for gaps no larger than 5 km between traverses. Effort should be concentrated west and south of Geeveston.
3. Augment marine data if possible as part of seismic survey. Definition of the gravity field in the estuaries and around the coast from Cape Queen Elizabeth to Tasman Head first priority.
4. All land stations should be barometrically levelled. See specifications.
- Reflection: Traverses should be located within the channel, estuaries and large bays as permitted by initial budget and availability of ship and equipment.

REFERENCES

- Amoco, 1971. Final report of the Cape Pillar marine seismic survey. Tas. tenement T11P. March 1971.
- BHP, 1966. Southwest Tasmania Aeromagnetic Survey, 1965-6. Mines Department Open File.
- Clark, C.J., 1972. A gravity survey of Bruny Island. Univ. Tasmania Hons Thesis.
- Cull, J.P., 1982. An appraisal of Australian Heat Flow Data. B.M.R. Jour., 7 (1), 11-23.
- Esso, 1965. Aeromagnetic survey Offshore Tasmania for Esso Exploration Australia Ltd., EL 17/65, 18/65, 19/65. Report by Geophysical Associates Pty Ltd, June 1967. Mines Department Open File Offshore 1.
- Finney, W.A., and Shelley, E.P., 1967. Tasmania Aeromagnetic Survey 1966. B.M.R. Recd 1967/19.
- Francombe, K., 1978. Magnetic survey - D'Entrecasteaux Channel and Derwent estuary. Univ. Tasm. Hons. Thesis.
- Leaman, D.E., 1972. Gravity survey of the Hobart District. Bull. geol. Surv. Tasm., 52.
- Leaman, D.E., 1975. Form, mechanism and control of dolerite intrusion near Hobart, Tasmania. J. Geol. Soc. Aus., 22 (2), 175-186.
- Leaman, D.E., 1976. Hobart. Explan. Notes. geol. Surv. Tasm.
- Leaman, D.E., 1981. Interpretation of geophysical surveys, Catamaran area, Tasmania (EL 6/79). Leaman Geophysics for Marathon Petroleum Aust. Appendix in 6 monthly report. See Mines Department open files 81-1639, 1606, 1769.
- Leaman, D.E., 1986. Gravity interpretation. West and Northwest Tasmania. Leaman Geophysics for the Tas Govt Mt Read Volcanics Project.
- Leaman, D.E., and Naqvi, I.H., 1967. Geology and Geophysics of the Cygnet District. Bull. geol. Surv. Tasm., 49.
- Rutter, H., 1983. Report on the Airborne magnetic survey of EL 40/83, Strathblane Tasmania. In first annual report for Marathon Petroleum Aust for period ending 21-9-84 (ed. D.O'Neill). Mines Department Open File 84-2200

APPENDIX ONE
PRELIMINARY SPECIFICATIONS FOR ADDITIONAL GEOPHYSICS
AS RECOMMENDED

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PROPOSAL 1:

AEROMAGNETIC SURVEY OF THE D'ENTRECASTEAUX CHANNEL REGION

Objectives: To provide a consistent magnetic coverage of the exploration area and its environs and to use this to generate an interpretation of pre-Permian structuring. The survey will also allow unification of other interpretations based on more limited data sets (gravity/seismic) as well as yielding assistance in evaluation of Jurassic dolerite structures.

Programme:

- a) To fly a fixed level survey at 1000 m using 2.5 km line spacings overall; orientation E-W. Tie lines at 5 or 10 km spacing. High resolution magnetometer.
- b) Process data to residual field and stacked profiles. Provision of contour maps of residual field.
- c) Preliminary interpretation of this data.
- d) Interpretation upgrades and correlation with other data as it becomes available.

Items (a) and (b) undertaken by contract, (c) and (d) by Leaman Geophysics. (d) will require use of 3D techniques.

Estimated cost: The actual cost is subject to quote but the survey as specified is estimated to cost between \$25000 and \$30000 including location expenses. Preliminary interpretation of the entire data set is estimated at \$4000 to \$5000 but 3D analysis of particular issues usually costs about \$4000 per problem tackled.

No reserve allowance has been provided for cost over-runs, supplies (below), or any additional coverage deemed desirable above that suggested.

Supplies: Successful tenderer requires a set of topographic base maps and recent airphotos.

Survey contractors for data acquisition:
 AUSTIREX, 27 Merriwa St., Gordon, NSW 2072 (02)4982299
 GEOMETRICS, 18 Gertrude St., Arncliffe, NSW 2205 (02)5974544
 GEOTERREX, 13 Whiting St., Artarmon, NSW 2064 (02)4383866
 AERODATA, 275 Alfred St., Nth Sydney, NSW 2060 (02)9232775

SPECIFICATION FOR AEROMAGNETIC SURVEY

DATA ACQUISITION AND PRELIMINARY PROCESSING ONLY

1. Survey area:

Centred on Woodbridge, Southern Tasmania. Hobart Airport some 35 km northeast. No controlled airspace.

Area to be covered specified by the following AMG coordinates.

470 000 mE to 550 000 mE; 5170 000 mN to 5250 000 mN flown east-west at a line spacing of 2.5 km.

2. Flight specification:

a) Fixed wing aircraft to be used.

b) Lines to be flown in an east-west direction.

c) Lines to be flown 2.5 km apart.

d) After recovery line position must deviate less than 20% from the specified position over 90% of the total line length.

e) In-fill lines to be flown at the operator's expense wherever line spacing exceeds specification by 50% for more than 10% of line length and are to cross two tie lines. This condition is waived in the region of the isolated high peaks between 470 000 and 490 000 mE provided the closest safe flight path at the survey level is flown around them. Lines over the Hartz Mountains must hold line but may drape the terrain (below).

f) Tie lines are to be flown normal to the traverse lines and have a spacing of 10 km.

g) Survey to be flown at an absolute level of 1000 m above sea level. Lines across the Hartz Mountains are to be draped at an approximate terrain clearance of 150 m. Terrain clearance to be recorded within 10 m on all lines.

3. Navigation and flight path recovery specifications:

a) All data to be collected in digital and analog formats.

b) A visual record for flight path recovery must be obtained whether it is the sole or part means of navigation.

c) The maximum distance between recovered points on each line will not exceed 2 km.

d) The resultant plan will be presented in the form of a navigation photomosaic, line transparency and line dyeline plan at 1:100000. Plans should show photo centres recovered, control points, AMG, and observation points if a Doppler system is used.

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4. Geophysical data specifications:

- a) Magnetic data will be recorded with a precision of 0.5 nT or 50 m or better.
- b) Up to 2 nT peak to peak noise levels will be considered marginal.
- c) The maximum acceptable error will be 3 nT after correction for diurnal variation with a reproducibility equal to this flown on a recorded test on each day of the survey.
- d) Magnetic base variations shall be observed and recorded.
- e) All data to be collected in digital and analog formats.
- f) Analog chart scales should maintain the highest sensitivity but, in addition, a record of the magnetic observations shall be made which maintains a single scale setting throughout.
- g) Records will not be accepted where magnetic field variations at the base station exceed 5nT in 5 minutes (non linear).

5. Digital record specification:

- a) Tape supplied to be 9 track, 1600BPI, fixed block, ASCII
- b) Records of navigation, magnetic and altitude data are to be provided.
- c) Each tape must be labelled as to flight line, content, date and evaluation code for reference.
- d) A tabulation listing instrument settings, scales and calibrations is to be provided for the record set.
- e) The evaluation code will prescribe the internal formatting of the recorded data.
- f) Details of all instrument specifications are to be provided.

6. Calibration specifications:

- a) Magnetometer and altimeter tests and calibrations to be made on each day of survey.
- b) Heading errors to be corrected within 0.5 nT prior to acquisition of data or acceptability of heading corrections established.
- c) The daily test may be made on any convenient alignment but records must be assembled and supplied at the end of field work.

7. Contour plan specification:

- a) Plans are to be produced at a scale of 1:100 000.
- b) Plans are to be prepared with contour intervals of 5 nT (accentuated 25 and 50 nT) except in areas of steep gradient where a reasonable contour density may be used.
- c) All plans to be supplied as transparencies and prints.
- d) The plan set must include a plot of recovered flight plot and control identification.
- e) All plans are to show the AMG grid.

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f) All plots for the survey are to utilise the minimum number of plan sheets. Wasteful or partial sheet usage is not acceptable.

8. Processing sequence:

- a) Correction for diurnal and storm effects and adjustment of ties.
- b) Residuation with respect to the IGRF.
- c) Contour map presentation.
- d) Stacked profile presentation.

9. All data derived from the survey will be the absolute property of the client and will be delivered to Leaman Geophysics, Hobart on behalf of the client at the completion of the programme. The data includes, but is not limited to, analog and digital records, tracking film etc.

10. Summary:

- a) East-west lines, spacing 2.5 km
- b) Survey elevation 1000 m.
- c) Residual field data presentation.
- d) High resolution magnetometry.
- e) Presentation of all analog and digital recorded data including radar altimetry.
- f) Line recovery and preparation of flight path plot.

TENDERERS SHOULD STATE:

1. Mobilisation fee, if any.
2. Magnetic data acquisition costs per line km.
3. Aircraft type.
4. Cost of line recovery and flight path plots.
5. Cost of processing and presentation of the data in contour plan and stacked profile forms.
6. Cost of preparation of any photomosaic or other flight reference materials.
7. Aircraft availability and payment schedules.
8. Clear acknowledgment of acceptance of specifications. Any queries or clarifications should be addressed to Leaman Geophysics, Hobart (002) 47 8849.
9. Equipment proposed to be used.

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PROPOSAL 2:

GRAVITY SURVEY UPGRADE D'ENTRECASTEAUX CHANNEL REGION

Objective: Regional structural assessment with particular reference to Jurassic dolerite and pre-Permian units. Gravity data interpretations to be integrated with deductions from magnetic coverage.

Programme:

Since much gravity data is already in existence with consistent and proven specifications the basic programme is designed to upgrade observation density to standards required in this project.

There are three options: In increasing cost, these are land in-filling, marine traverse (as part of seismic survey) or airborne.

In all cases the coverage must be improved beyond the immediate confines of the exploration areas. The programme presumes that only land filling and perhaps some marine acquisition is likely.

a) Acquisition

LAND Regional observations to reduce gaps to less than 3 km; 1.5 km within licence areas. Observation on all small islands.

MARINE As part of seismic survey.

b) Reduction and correction of data and incorporation in existing data base.

c) Preparation of contour maps.

d) Preliminary gravity only interpretation.

e) Evolved interpretation using cross control with magnetics for detailed definition of particular structures.

Data acquisition by contract. Specification, supervision and interpretation by Leaman Geophysics.

Estimated costs: Uncertain since coverage density dependent on budget provisions but \$15000 will provide a reasonable data base upgrade on land. Any marine costs would be included in any seismic cost. A basic overall interpretation would cost about \$5000 and detailed iterations of particular structures or targets a similar amount. No allowance has been made for any more detailed local coverages found desirable.

Supplies: One set of basemaps and airphotos.

Contracting observers:

SOLO GEOPHYSICS, 3A McInnes St., Ridleyton, SA, (08)468277

WONGELA GEOPHYSICAL, 22 Kurraba Rd, Nth Sydney, NSW, (02)921788

SPECIFICATION OF GRAVITY SURVEY

1. Survey area. 470 000 mE to 550 000 mE
5170 000 mN to 5250 000 mN

Base station (ultimate): Hobart Airport.

(local): To be determined- a new base net may be installed. Old ties are available at Snug, Cygnet, Franklin, Dover.

2. Survey specifications:

- a) Road and track traverses. (selection to be made)
- b) Nominal station spacing on traverses to be 1 km.
- c) Gravimeter loop times not to exceed 3 hours.
- d) Barometer elevation determinations using methods of Leaman (1984)- see APPENDIX 2 - including base barometry, field barometers, controlled looping techniques. Precise traverse and field work plan to be provided. The base barometer should have a precision of no less than 0.1 mB and the field instruments should be digital and readable to about 0.05 mB.
- e) Reproducibility of gravity observations: 0.03 mGal.
- f) Close to station descriptions to be provided.

3. Data:

All data to be presented to Leaman Geophysics, Hobart in field notebook form complete with station location descriptions for correction and reduction. The observer/contractor will not be required to make any corrections or data reductions, whether of elevations or meter readings.

TENDERERS SHOULD STATE:

1. Mobilisation fee, if any.
2. Availability and payment schedule.
3. Cost per day for gravity meter, observer, base barometer and at least two digital microbarometers.
4. Type of instruments proposed
5. Date of most recent calibration.

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PROPOSAL 3:

MARINE SEISMIC SURVEY

Objective: Detailed control of the forms and relationships within the pre-Permian section. Localised control of gravity and magnetic interpretations.

Programme: a) Traversing of estuaries for general framework.
b) Co-acquisition if possible of marine gravity data.
c) Processing as specified and presentation in section form.
d) Interpretation.

Acquisition and processing by contractor; interpretation by Leaman Geophysics. Interpretation linked to review and updates of gravity and magnetic interpretations.

Estimated costs: No realistic cost estimate can be provided at this time since the ultimate specifications will depend on negotiation with the contractor after review of ship size, depth constraints, manoevrability and streamer length.

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SPECIFICATION OF SEISMIC SURVEY

As noted above no final specification of such a survey is yet possible due to considerations related to the geography of the region and the equipment available to undertake the survey at reasonable cost.

1. Survey area:

D'Entrecasteaux Channel and Huon estuary, southern Tasmania

Detailed traverse locations, number and position to be negotiated.

2. Survey acquisition specification: Most details to be confirmed including streamer length, hydrophone groups, spacing, fold etc. Very high energy source will be required to overcome shallow extreme acoustic contrasts.

- a) Record length: 5 seconds.
- b) Sample interval: 2 msec.
- c) Recording filter: HI 128Hz/72DB; LO 8Hz/18DB
- d) Format: SEG D or equivalent
- e) Gain: IFP

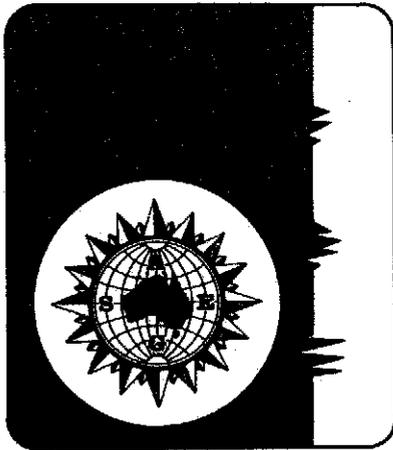
3. Digital processing: Full details to be reviewed upon acquisition when the precise needs of this relatively unique data set can be assessed.

- a) Static corrections for streamer and shot depths.
- b) CDP sort (minimum 12 fold)
- c) Equalisation 500 ms AGC
- d) Deconvolution as required subject to test.
- e) Velocity analysis: 1 per 4 km approx or equivalent number of CDP points.
- f) F/K multiple suppression.
- g) Review of velocity analysis at 1 per 2 km.
- h) NMO muting if necessary.
- i) CDP stack (minimum 12 fold)
- j) Filtering as required subject to test.
- k) T-V windowed scaled equalisation.
- m) Maintenance of polarity throughout.

4. Gravimetry: Presuming the ship carries the necessary facilities observations should be made each 20 to 30 seconds. The following are to be recorded: Fix or line number, date, time, raw navigation data, coordinates at fix time, raw gravity values, type of filter used, ship's heading, course over ground, speed and waterdepth. The precision of ties or repeatability of reduced gravity not to exceed 0.5 mGal. Results to be corrected for drift, instrumentation and Eotvos fields and presented in Free-air and Bouguer forms (2.67 t/cu m).

5. Positioning: Positions must be stated within 50 m.

APPENDIX TWO
NOTES ON MICROBAROMETER ELEVATION DETERMINATIONS



Notes on Microbarometer Elevation Determinations

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Key words: barometers, elevation, height determination, gravity surveys

Abstract

Barometers are frequently used to provide elevation control data for gravity surveys. Provision of reliable elevations by this means is not straightforward and depends on an appreciation of physical reduction factors, such as temperature or elevation itself, field technique and selective rejection of some observations. Data redundancy is essential.

The theoretical and practical issues which affect interpretation of barometric data are briefly reviewed. Most errors can be traced to instrumental variability, observer inconsistency, inadequate controls or atmospheric abnormalities. An elevation accuracy of 1 - 1.5 m is possible given care in survey design and practice.

Barometric elevation determinations in variable terrain must be based on careful, multiple and controlled observations. Pressure distortions within the atmosphere or around topographic features may invalidate many field techniques including those using base barometers. Considerable manual involvement is advised throughout the reduction process and unfortunately no simple universal sequence can be recommended. Local conditions must be uniquely assessed.

Introduction

This paper provides a brief outline of the theory and issues involved in barometric elevation determinations. There are few references in the literature to this important topic and even fewer describing the pitfalls. The paper is intended to caution new or inexperienced users concerning barometer usage and to suggest those factors which must be borne in mind at all times and which yield optimal results. There is no simple, rigorous solution and the observations may need as much interpretation as any gravity data collected with them.

The notes have been distilled from 20 years experience with barometers of various types in a wide range of climatic conditions. The problems described are exacerbated by high temperatures as in northern Australia, or in any hilly terrain. As many major and some minor gravity surveys are dependent on barometric elevations it is important that techniques are employed which can provide the desired reliability. The yield and effectiveness of many gravity

surveys is directly related to appreciation of barometer issues and any field or processing compromises made. Much industry distrust of gravity surveys can be traced to this topic. (Regional separations are another source.)

The writer has evaluated many techniques in an effort to develop economical and reliable barometric reduction procedures. This process was begun in 1966 when the problems were first recognized in a survey lacking optical control but requiring an elevation accuracy better than 1.5 m. This is easy in theory (see below) but practical considerations render the goal attainable only with difficulty and good technique. Every barometric survey since that time has been undertaken with an insistence on observation redundancy. Some interpreted results are tested against control or survey level independently of the original reduction which may have used other control information.

The general ignorance relating to this topic is due to the apparently simple reduction process and the casual treatment offered in geophysical texts. For example, Telford *et al.* (1976) state on page 46 that an accuracy of ± 0.3 m is possible, especially if two barometers (one a base) are used. The Bureau of Mineral Resources helicopter surveys in Australia were undertaken using barometers and the results have been evaluated (e.g. Darby 1970; Shirley 1979). Using a rigorous field technique and a control system the mean error was at least 2 m with a significant number of stations possessing probable errors in excess of 3 - 4.5 m (4 - 6 m; Barlow 1977). Even moderate errors such as these imply an error of at least 1 mgal ($1 \text{ mgal} = 10 \mu\text{m s}^{-2}$) in the Bouguer anomaly. Smaller scale surveys, undertaken with rigour and control, can be expected to yield improved results. Many, if not most, surveys are undertaken with much less care. Disguised errors in excess of 50 m are possible with poor technique. Errors of 10 m are probable without critical review and application of the principles described below.

The reviews undertaken have demonstrated several consistent aspects. Errors are related to the form of the terrain, the nature and placement of the control points and the field techniques used. Several of these issues were raised and proposed for research by Darby (1970). The writer has tested various field techniques and refined specifications over several years with a view to obtaining a general accuracy better than 2 m (or 1 - 1.5 m for most stations) in a survey.

However, the continuing general commercial use of apparently sophisticated but less reliable methods is the primary reason for these cautionary notes.

Barometric reduction

Barometric elevation reductions are based on equations of the form

$$h = - \ln \frac{p/p_0}{Mg/RT}$$

Derivations are given in most physics texts (e.g. Halliday & Resnick 1961, p. 359).

Where h = height difference between station and base/control or reference point; p = pressure at observation point; p₀ = base pressure or pressure at control point or known height; M = molecular weight of 'air' (approx. 29); g = acceleration due to gravity; R = gas constant; T = absolute temperature.

Inspection of the equation shows that any evaluation of elevation differential depends directly on air temperature, reference pressure and inversely on elevation, humidity and variations in gravity. Most of these need little explanation. The relationship between actual elevation and h and actual elevation and reference pressure is subtle. (This is discussed below.) The role of reference pressure can be inferred but may itself be a function of elevation or lateral atmosphere change.

A properly calibrated barometer, corrected for atmospheric conditions, can provide height difference precision commensurate with instrumental precision. The problems of atmospheric definition and instruments are outlined below and destroy this 'text book' illusion.

Firstly, the physical derivation assumes an atmosphere free of any discontinuities. Surveys passing in and out of cloud, or other weather changes, or atmospheric inversions, clearly do not meet this condition. An inversion occurs when the air temperature increases with altitude (normally it decreases) and may be relatively insidious since it may not be apparent to the observer. The other problems can be avoided (at the cost of no operation) while the conditions persist.

Secondly, it is usually impractical to undertake all the measurements either at a base or at the observation points for labour, cost or portage reasons.

Finally and crucially, the atmospheric pressure function is rarely a simple exponential due to the effects of the terrain. Severe errors can be induced where the survey moves into hilly country with its multitude of local climates, some related to cloud/sun cover, and pressure differentials. A hill less than 1 km across at the base and 200 m high may induce a substantial atmospheric drape effect, which may change according to ground temperature, down draughts, or time of day. Local temperature variations may be governed by vegetation type and cover or rock type, especially if exposed. Loss of horizontal stratification in the atmosphere, for any reason, is the source of most large errors (> 5 - 10 m). Where topographic features interlock to form valleys and divides, or are larger than the size quoted above, the problems compound.

If frequent or rapid pressure changes, such as are common in temperate climates, are superimposed on such a terrain then barometric determinations may be very uncertain. Every day in the survey will be unique in its presentation of ground/terrain covered, atmospheric state, sunshine, superimposed effects and traverse conditions. Thus it is often found that the results of one day may be better than the next using a standard specification, especially if standard base barograph methods are used in isolation (see below). So called 'stable' days, with smooth inversion effects, are not free of these defects.

All the variables may overlap in the typical terrain of eastern and southern Australia. Conditions are better west of the dividing range because the flatter terrain and more uniform daily - weekly climate distant from the ocean allows the atmosphere to more closely approach ideal conditions.

Reduction can be effected by direct computation or by graphical methods with or without accessory information (e.g. temperature). Graphical methods can take various forms including:

- (i) log p/p₀ vs h;
- (ii) p-p₀ in mb vs h/mb;
- (iii) p vs h/mb (1 millibar or mb = 100 Pa = 100 N m⁻²).

A graph of type (iii) is shown in Fig. 1. Note that it includes several plots for reference pressure and should be duplicated for a range of temperature and humidity conditions. It yields a pressure - height difference multiplier. Figure 1 also allows some factors to be evaluated. Consider a station pressure of 980 mb and a base pressure of 1025 mb. The pressure difference is -45 mb (i.e. the station is at a higher elevation) and at 20°C the height difference is 45 x 8.54 = 384.3 m. The effect of a different reference pressure, say 1013 mb, is evident: 45 x (8.60 - 8.54), or 2.7 m. At 30°C the multiplier is 8.8 m/mb and the implied difference is 396 m. Humidity differences may have effects comparable to temperature changes of 1 - 5°C but generally occur over longer intervals and are rarely as critical. Variations in g are not significant.

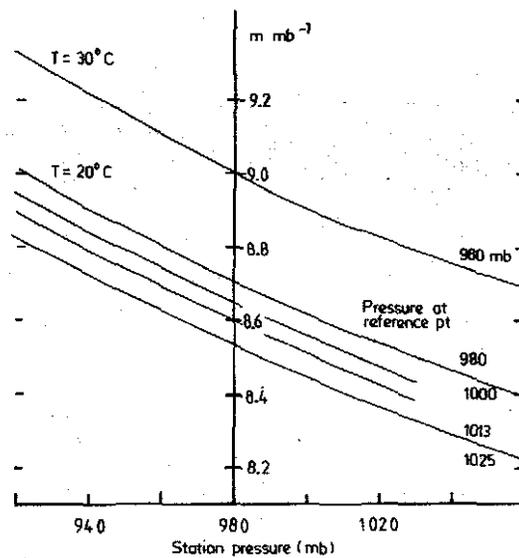


FIGURE 1 Pressure - height difference function.

Microbarometer elevations

These procedures are easily computerized. Unfortunately, other factors [a complex field note book (see below) and the advised level of manual intervention] often make general processing undesirable and difficult. Manual, calculator-assisted methods are most efficient (e.g. using a small, programmable calculator).

About barometers

Most microbarometers, especially modern digital types, can be read to 0.01 or 0.02 mb, and all can be read with confidence to about 0.05 mb. They may in theory be used to resolve height differences of about 0.1 - 0.4 m but, as noted above, there are other factors involved. The need for well-maintained equipment cannot be overstressed and the precision quoted above is often suspect. Few long term users of barometers will be unaware of reproducibility problems. Barometers must be regarded as relatively crude devices which do a good job in the circumstances.

Most manufacturers supply a calibration (and perhaps correction chart) with their instruments. The writer does not believe the conditions of calibration to be particularly important provided the temperature is in the range of 10 - 25°C and the instrument records the absolute pressure within the precision stated across the pressure range likely to occur in the survey area. As will be seen in Table 1, not all instruments read correctly.

In addition, operators must be trained in the care and use of these instruments. Such training should include insistence on observation procedure consistency (up to 0.3 mb difference may be noted between readings up or down to the pressure), maintenance of consistent orientation to any wind, avoidance of 'field' adjustments, and gentle handling. The effect of wind, or wind shelter, may be significant. The field book should note wind condition, if variable, in case a station (or set) becomes suspect later. A barometer should also be allowed to stabilize for at least a minute before observing [longer on cold (< 10°C) days].

Field techniques

The most common field technique utilizes a base barometer. In this method, observations made with a roving barometer (or barometers) are corrected by reference to changes and times noted at the base. This technique has been tested in various terrains but in hilly areas it does not yield results better than 2 - 5 m where the field station is more than ± 50 m or $\pm 500 - 1000$ m from the base in elevation or position. Reliability is better in flat country with uniform vegetation.

Where the elevation difference exceeds 50 - 100 m and the base is located in a different topographic relationship to the weather (e.g. other side of a hill, foot of slope, etc. or is more distant than 1 km) errors may exceed 10 m. Drapage, local climate or time delay effects, respectively, are at work. The time delay effect may be very important in the case of a deep cold front (especially if slow moving) since the time of crisis may not be known along the traverse even though its shape and passage is known at the base. Topographic forms also distort and diffract the pressure front. Errors from this source may reach 25 m. Early afternoon pressure declines in the north Australian winter may be just as important (e.g. Fig. 2).

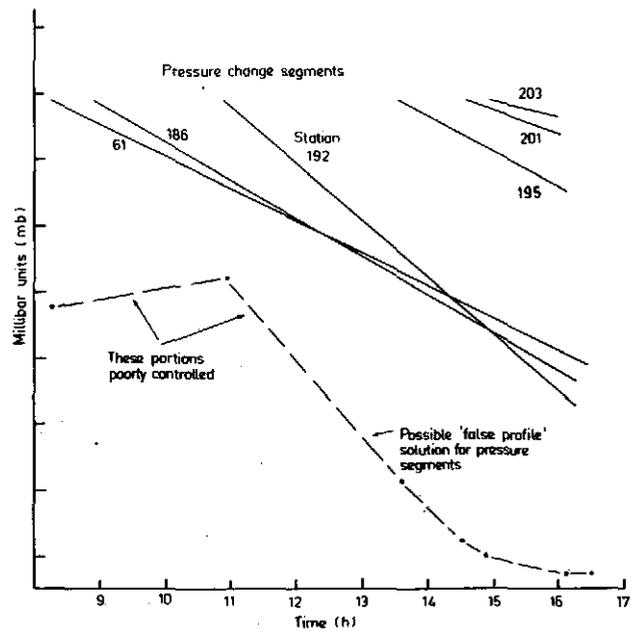


FIGURE 2
'False profile' pressure - time construction.

Problems may persist even where 2 h loops have been observed, since loop time makes no allowance for the route of the loop. Problem identification may be difficult since no one station will be obviously in error since many stations in a set will contain a systematic error function if the interval between stations is relatively short. Multiple base stations have also been tested (as suggested by Darby 1970) but this variation imposes many logistic and equipment problems and was only useful in relatively flat terrain where it did resolve some time delay errors.

The discussion neglects some common deficiencies in the commercial use of recording barographs. Few have a presentation precision comparable with the field meters, their time scales are often awkward, 0.1 mb is often the best precision, thick ink lines obscure important detail, pen friction leads to loss of fidelity and disagreements on differences for the day are often encountered (Table 1). A manual observer is a better if unrealistic solution.

The second method uses differences between stations and may be called the 'point to point' method. Each traverse must be end-controlled and should include some internal control. The amount of control and accuracy required will govern the timing and separation advisable. The method can be employed without base control but this is bad practice unless the station spacing is only a few scores of metres. Drapage problems may not be resolved without adequate control.

A third method may be termed the 'false profile' method. It was developed during early research and requires the construction of a time - pressure curve for the stations of the loop/day by collecting repeat observations. Each pair of repeats yields a line segment for the pressure change in the interval. If enough segments have been observed a unique reconstruction of pressure versus time, along the traverse, is possible. Segments must overlap and fine detail depends on the number of segments. The profile has the

TABLE 1

A typical field set of barometer readings (mb) from a regional gravity survey where some repeats were specified. Note that failure to observe at intervals during the breakdown in the middle of the day has reduced the reliability of the entire set. Stations marked * are examined further in Table 2.

Station	Time	Bar 1	Bar 2	Bar 3	Base corr	F.P. corr
61	0815	985.12	985.03	987.40	0.00	0.00
184*	0831	982.03	982.04	984.09	0.00	-0.05
185	0843	982.24	982.38	984.73		
186*	0854	984.09	984.26	987.03	0.00	-0.10
187	0906	983.88	984.38	986.65		
188*	0934	984.64	984.92	987.38	-0.05	-0.15
189	0947	983.81	983.92	986.46		
190*	1011	983.55	983.66	986.06	-0.10	-0.25
191	1048	983.75	984.04	983.35		
192*	1054	981.89	982.12	984.53	-0.05	-0.40
193	1103	982.42	982.30	984.64		
194*	1326	977.88	977.70	980.36	1.40	2.50
195*	1335	979.24	978.95	981.75	1.50	2.60
196	1347	978.12	977.98	980.51		
197	1357	979.00	979.13	981.45		
198*	1412	976.33	976.36	978.90	3.50	3.25
199	1421	977.72	977.89	980.32		
200*	1429	978.96	979.05	981.55	3.80	3.50
201	1438	979.24	979.46	981.80		
202*	1444	978.21	978.29	970.66sic	3.90	3.70
203*	1453	978.82	978.91	981.32	4.10	3.80
204	1503	974.50	974.73	977.30		
205	1514	975.74	975.90	978.38		
206*	1527	978.93	978.80	981.42	4.30	3.95
207	1533	979.26	979.22	981.67		
208*	1540	979.25	979.50	981.92	4.40	4.00
209	1546	976.46	976.36	978.75		
203*	1558	978.72	978.66	980.97	4.50	4.05
201	1601	978.84	978.85	981.22		
195*	1608	977.97	977.82	980.10	4.50	4.05
192	1612	977.35	977.56	989.95		
186	1617	979.70	979.66	982.20		
177	1623	980.46	980.54	983.00		
61*	1628	980.95	981.07	983.42	4.50	4.05

form of a base record but there are important differences. Time delay effects are minimized or removed and some allowance for terrain variations is built in. Errors are often reduced by half when contrasted with conventional base methods and can be improved further if control can be applied to any points during the day. Such points can be back calculated to adjust the profile if necessary.

An example of such a profile using the poor data of Table 1 is shown in Fig. 2. The term 'false profile' is used since the plot is an integration of many factors. Its greatest value lies in relating base events to times on the loop. It can be used in lieu of a base record but its value is related to the number of repeats collected. The acquisition of many repeats usually means tight control on unknowns if known heights have been entwined, and the use of the false profile may be unnecessary.

A fourth method uses several roving barometers. This is truly a Pandora's box. It does not solve any of the problems described above but reveals the scale of instrumental variation (e.g. Table 2). Variations may exceed 0.3 - 0.5 mb with

no systematic link to any meter. The moral: do not use single barometers if you can avoid it! The problem: which values/value is to be accepted? The writer, having agonized over many sets of multiple barometer observations, cannot recommend a simple, universal solution but a satisfactory approach is to examine loop base to station differences or station to station differences and select the most consistent pairs while checking any overall intervals (Tables 2 and 3). There are inevitably difficulties and some judgment may be required.

The common practice of averaging is not recommended. In many cases the error may be less than 0.2 mb for a single station but may exceed 0.4-0.5 mb in inter-station differences. Erratic deviations are permanently incorporated when manual rejection might have been possible. Values still need correction for the usual pressure change as defined by false profile or base records. A minimum of three barometers is suggested and they should be properly calibrated and compensated. Many instruments are in use which confront the user with columns of quite different numbers. Table 1 illustrates a number of these points. It is

TABLE 2

Height conversion sequence, stage one. The adjustments applied are based on the 'false profile'. Note that the misclosure represented by 61 would have been avoided if the better 61-61 drift value of -3.97 had been used. This deviation also accounts for much of the variation noted for 195. This shows the importance of care in observation and reduction decisions. Height conversion factor: 9 m/mb

Station	Pre-correction differences with respect to 61 (mb)			Value accepted	Adj.	Diff.	Height diff.
184	-3.09	-2.99	-3.31	-3.05	-0.05	-3.10	+27.9
186	-1.03	-0.77	-0.37				
188	-0.48	-0.11	-0.02				
190	-1.57	-1.37	-1.34	-1.36	-0.25	-1.61	+14.5
192	-3.23	-2.91	-2.87	-2.89	-0.40	-3.29	+29.6
194	-7.24	-7.33	-7.04	-7.28	2.50	-4.78	+43.0
195	-5.88	-6.08	-5.85	-5.87	2.60	-3.27	+29.4
198	-8.79	-8.67	-8.50				
200	-6.16	-5.98	-5.85				
202	-6.91	-6.74	-6.74	-6.74	3.70	-3.04	+27.4
203	-6.30	-6.12	-6.08	-6.10	3.80	-2.30	+20.7
206	-6.19	-6.23	-5.98	-6.20	3.95	-2.25	+20.2
208	-5.87	-5.53	-5.48	-5.50	4.00	-1.50	+13.5
203	-6.40	-6.37	-6.43	-6.38	4.05	-2.33	+21.0
195	-7.15	-7.21	-7.30	-7.18	4.05	-3.13	+28.2
61	-4.17	-3.96	-3.98	-3.97	4.05	0.08	- 0.7

TABLE 3

Height conversion sequence, stage two. Evaluation of intervals between consecutive stations where overall differences with respect to reference point are irregular.

Station	Intervals between barometers (mb)			Uncorrected accepted value
184				
186	2.06	2.22	2.94	2.12
188	0.55	0.66	0.35	0.60
190	-1.09	-1.26	-1.32	-1.29

commercial data. Note that the barometers neither read the same value nor are consistent in differences. The table also shows that the base record is not consistent with the field barometers; the difference is about 0.5 mb, or 4.5 m. The problem is how to assign such a discrepancy. The table is somewhat exceptional in the number of repeats but they are too few and loop times are too long. The false profile is better than the base record but poorly controlled. In this area spot heights and trigs were available and should have been observed — as stated by specification — and noted along with weather conditions in the field book.

Table 2 indicates some of the interpretation problems. Station 61 is a tie point and in the approach shown differences have been calculated with respect to it. Two groups emerge; one with pairs within 0.1 mb and another very uncertain. The proportions are typical, even though this was a stable day in flat terrain. The problems are usually compounded on windy days or in rougher terrain. Table 3 indicates one method of resolving the second station group, by differences with respect to each other which may then be linked to the other stations.

Some alternate methods can be reviewed by calculations on 184: a non extreme example in this set.

Uncorrected for base:

By average difference from 61: $-3.13 \times 9 \text{ m/mb} = 28.17 \text{ m}$

By selected value method: $-3.05 \times 9 \text{ m/mb} = 27.45 \text{ m}$

0.72 m

The nominal error, even in good observations, is about 0.05 mb (or 0.5 m) and poor field technique, atmospheric problems and inadequate processing can rapidly escalate the error. (Note the value of 0.72 m above.) None of the above calculations has made any allowance for temperature and a 10°C variation during the day could have induced a maximum error of about 3 m in a range difference of only 8 mb. Shorter loop times or more control points can reduce the need for temperature measurements but the best result will still carry a possible error of 0.5 - 1 m.

The problems induced by atmospheric distortion around topographic features or changes in vegetation and ground temperature can never be fully defined although the effects can be minimised by survey design.

Tests have shown that acceptable reliability in elevation determinations is possible using only a combination of point-to-point and false profile methods. There are several critical conditions:

(1) A control point known to an accuracy better than survey need should be observed at no more than 1 h intervals.

(2) Every other possible height estimate must be checked barometrically. If the area is topographically contoured any estimate of restricted features (e.g. cols) will help. Photogrammetric machine plots may be available. Side trips may increase survey time but the control, even if rough, is worthwhile. The field book will be complex.

(3) Control points, whether estimates or trigs, must be observed at sites comparable physically to the unknown stations; neither too distant (preferably 500 m) laterally or vertically (50 m). Wherever possible, observe the control points gravimetrically.

(4) Where control points are unavailable, as is the case for much of the country, or where several stations must be observed between control points, especially on slopes, ensure that sufficient repeat readings are obtained to construct a sound false profile. It may sometimes be necessary to optically install a coarse tie network. In hilly terrain with limited control data establish 'bench' factors for the drape function up the slope since it will often be found that the barometers will overestimate the height of the feature. For such tests, or for a survey where some control is possible, place the stations between a low level control point (c1) and a high level point (c2). Suppose stations are as shown in Fig. 3.

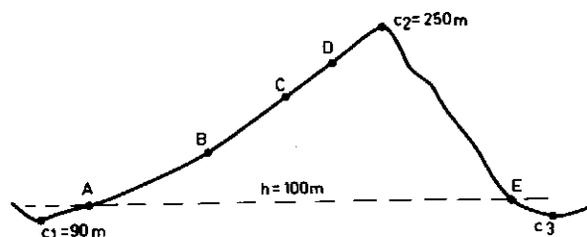


FIGURE 3

The set c1, A, B, C, D, c2, E, c2 may be adequate with E probably faulty; c1, A, B, C, c2, D, c2, E, c3 (or c1) will be better. It is possible that either c1, A, B, C, c2, D, c2, E, B, c1 or c1, A, B, C, c2, D, c2, C, E, c3, D, B, c1 would be necessary to properly define the atmospheric condition, depending on the time taken to traverse the hill. The set c1, A, B, C, D, E, c1 will be quite unreliable. c3 is an estimate value.

(5) Attempt some form of barometer controlling observation every 15 to 20 minutes at least. This may take the form of a repeat of a station previously read that day or any previous day, a spot height or estimate control.

(6) Cross link stations from different loops and especially any loops observed on previous days. An overlapping loop system, such as figure of eights, may permit this efficiently depending on the overall survey specification. Loop ties will provide an indication of the likely

errors and allow some feedback adjustment against the available control points.

The coupling of a base barometer to the above technique, though not essential, is recommended since it permits continuous and specific refinement of any on-traverse false profile construction. Use of a group of roving barometers is also recommended. It will be evident that these are quite demanding and time-consuming conditions; more demanding than those for the gravity survey whose major errors will be due to elevation deficiencies. Conventional least squares network adjustments are feasible and should be undertaken in the height rather than pressure domain for those cases where control is restricted or absent. In such cases tight loops and multi-day cross ties are suggested if errors are not to exceed 2 m. Some of the stations most at risk, such as those at the foot or top of topographic features, should be repeated. Where a complex set of ties, repeats and controls is possible errors should be adjusted giving due weight to the status and control of stations. This will vary from loop to loop according to weather and ties used. The general use of network adjustments is then invalid. The interpreter must decide which segments are good and which are doubtful. Comprehensive field notes are indispensable.

Comment

It may be thought that errors of the magnitudes indicated should be recognizable in any derived Bouguer anomalies. This is not generally the case since most errors are smoothly concealed in a station set and unless loops based on different day, or control, assumptions interlock such errors may never be suspected. Properly controlled and corrected loops usually interlock within ± 1 m. Exceptional barometer deviations can be isolated by use of several barometers.

Where base barometry provides the sole reference system every station may be in error and loop interlocks are essential. False profile errors, by contrast, tend to occur on poorly controlled extrapolations within the construction but these are obvious. The scale of the error may not be obvious but it will be less than the base station case.

This discussion has probably suggested some solutions or further questions to the reader. These might typically include:

(a) 'Barometers should never be used.' This is a good idea but is not always practical. Most semi-regional gravity surveys require an r.m.s. error in the Bouguer anomaly of about 0.5 mgal. Barometers can estimate elevations within the 1.5 - 2 m required provided great care is exercised.

(b) 'What is the best way to process the observations?' It has been suggested that simple field procedures readily amenable to computer manipulation are rarely appropriate. Much additional detail of various types and some judgment is required; the results reflect the field and processing effort and there are few short cuts. Methods using programmable calculators and manual methods are most reliable.

(c) 'We never have this problem.' The writer advises any readers of this belief to randomly check some surveys. For example, errors in regional BMR surveys were typically about 4 - 6 m, using a reasonable proportion of control traverses. Many surveys do not approach even this level of reliability but the gravity data are treated as though the elevations are much better known.

The aim of these notes was to suggest that it is possible to achieve accuracies of better than 2 m but at a higher price than is regularly paid at the present time.

Conclusions

Barometric field techniques, especially when applied in hilly regions, or areas subject to major atmospheric pressure changes, must include frequent observations at known or estimable heights and/or include many repeat observations. Repeat intervals should be as short as possible although a range of interval times will occur over the survey day. Some form of control reading is recommended (where possible) every 15-20 min and the control point should be climatically and topographically representative of the unknown points.

Atmospheric drapage errors may be minimized using adjacent control references. A rarely attainable ideal is $c1, A, c1 \dots$, where the unknown is sandwiched between two known points. Pressure change events can be identified on uncontrolled traverse segments by construction of false profiles based on repeat readings. Such profiles are usually more reliable than base station records.

Many gravity surveys may have suffered due to inadequate field technique and specification. Barometer usage specifications should be more rigorous than those for the gravimeter, although this is not a view held by most operators. Barometers need careful handling and must be used in a consistent and planned way. Data redundancy must be

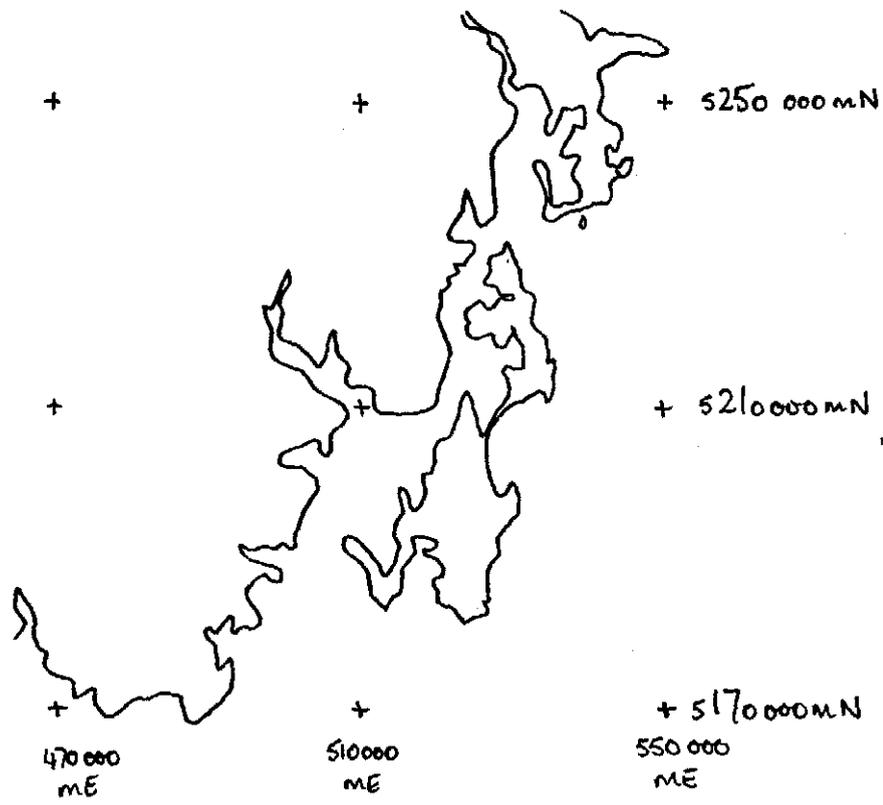
acquired. There is no simple, rigorous universal solution to the pressure reduction problem and each survey with its particular requirements (local terrain, climate, access, and controls) will pose unique problems.

The above comments notwithstanding, appropriately specified gravity surveys using barometers are feasible and can yield high quality results at a cost much less than any alternative means of height determination. A survey requiring an accuracy of about 0.3 mgal and hence 1.5-2 m in height can be entrusted to barometers if all due care is taken. A range of field methods will be required and multiple barometers should be used.

References

- Barlow, B. C. (1977), 'Data limitations on model complexity; 2-D gravity modelling with desk-top calculators', *Bull. Aust. Soc. Explor. Geophys.* **8**, 139-43.
- Darby, F. (1970), Barometric heighting — an assessment of the accuracy achieved during reconnaissance gravity surveys in Australia. Bureau of Mineral Resources (Australia) Record 1970/89 (unpubl.).
- Halliday, D. & Resnick, R. (1961), *Physics for Students of Science and Engineering*, John Wiley, New York.
- Shirley, J. E. (1979), 'Crustal structure of north Queensland from gravity anomalies', *BMR J. Aust. Geol. & Geophys.* **4**, 309-21.
- Telford, W. M., Geldart, L. P., Sheriff, R. E., Keys, D. A. (1976) *Applied Geophysics*, Cambridge University Press.

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OVERLAY FOR FIGURES 16, 17 AND 18

Diagram may be used to replace transparent overlay supplied.

FIGURE 28

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Report submitted on behalf of
Leaman Geophysics
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Appendix 4

REVIEW OF THE HYDROCARBON PROSPECTIVITY

OF EL 29/84 ONSHORE TASMANIA

J. N. Mulready
Mulready Consulting Services
April, 1987.

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APPENDIX 2: Analysis of seep sample by ANALABS

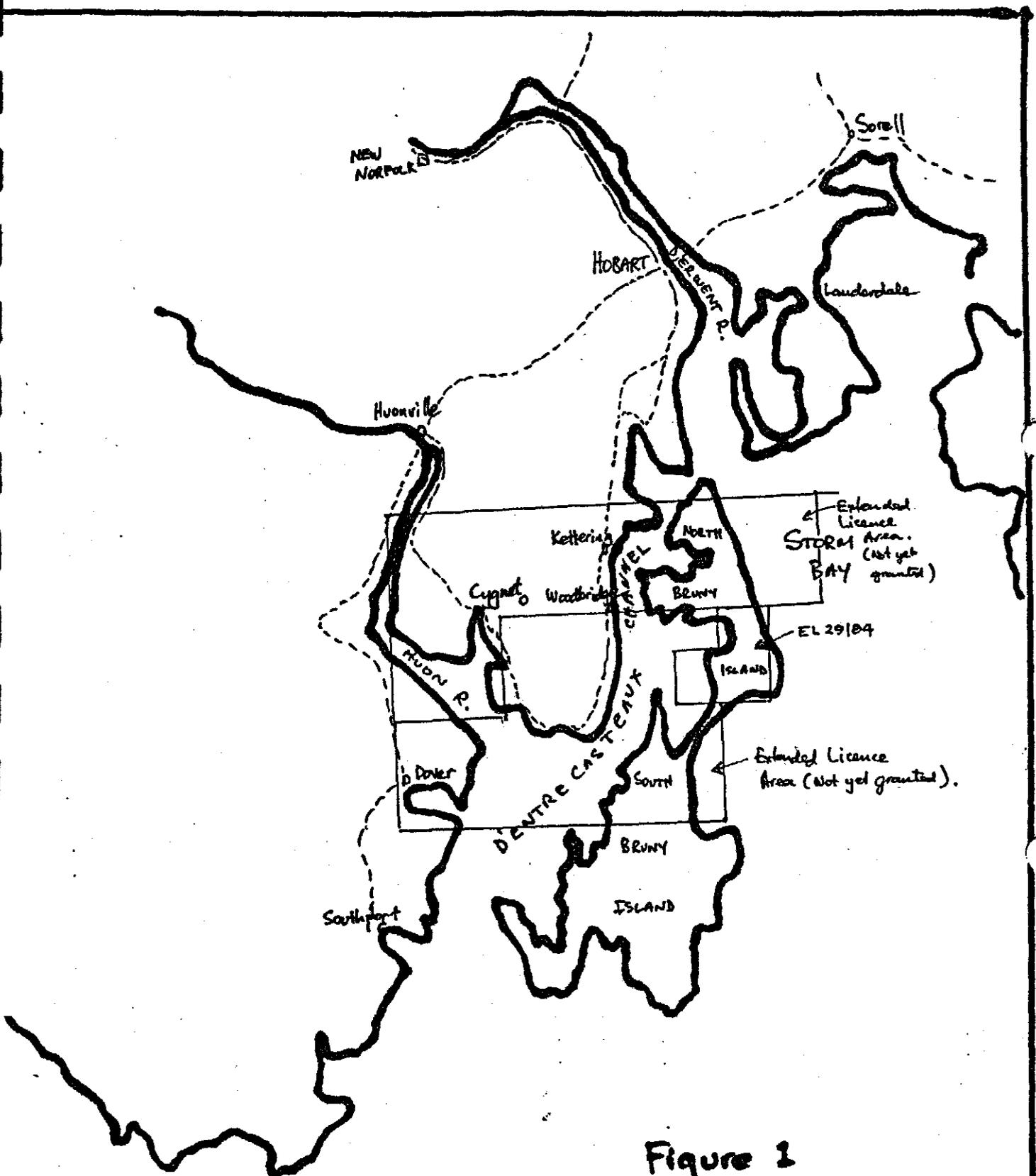


Figure 1
LOCATION MAP

INTRODUCTION

This report has been prepared at the request of Conga Oil Pty. Ltd. and is intended as a summary of the progress of exploration in EL 29/84 to date. Additional areas adjacent to EL 29/84 are subject to application by Conga Oil but had not been granted as of the date of this report.

All available relevant sources of information have been consulted (refer Bibliography), and the writer is particularly indebted to Dr. David Leaman (Leaman Geophysics), Dr. Clive Burdell (University of Tasmania), and Mr. Malcolm Bendall (Conga Oil) for the assistance provided by them in the preparation of this report, which of necessity draws largely on their work.

Exploration to date (geophysical studies integrated with regional geology, conodont studies of the Ordovician section, and analysis of the Johnson Well seep), suggests that a substantial pre-Permian sequence may be preserved beneath the base Permian unconformity at North Bruny Island, within EL 29/84 (refer Fig. 1). By analogy with the known geology of Southern Tasmania it is anticipated that this section will be of Lower Palaeozoic Age (Cambrian-Silurian/Devonian), with sourcing of hydrocarbons attributed to the Ordovician carbonate sequence (Gordon Limestone). Possible reservoirs are the Silurian clastic sequence (Eldon Group), and the source sequence itself (Gordon Limestone). The structural style is expected to involve folding and possible thrusting but detailed analysis of this aspect is not possible on the data presently available.

EL 29/84 is located approximately 29 km south of Hobart and includes part of North Bruny Island and small parts of the D'Entrecasteaux Channel and Storm Bay (refer Fig. 1). Access to Bruny Island is by ferry from Kettering. There is an excellent road running the length of both islands providing access to much of the permit area, although some parts are difficult to access due to thick tree cover, steep terrain and gullying.

STRUCTURAL ELEMENTS TASMANIA

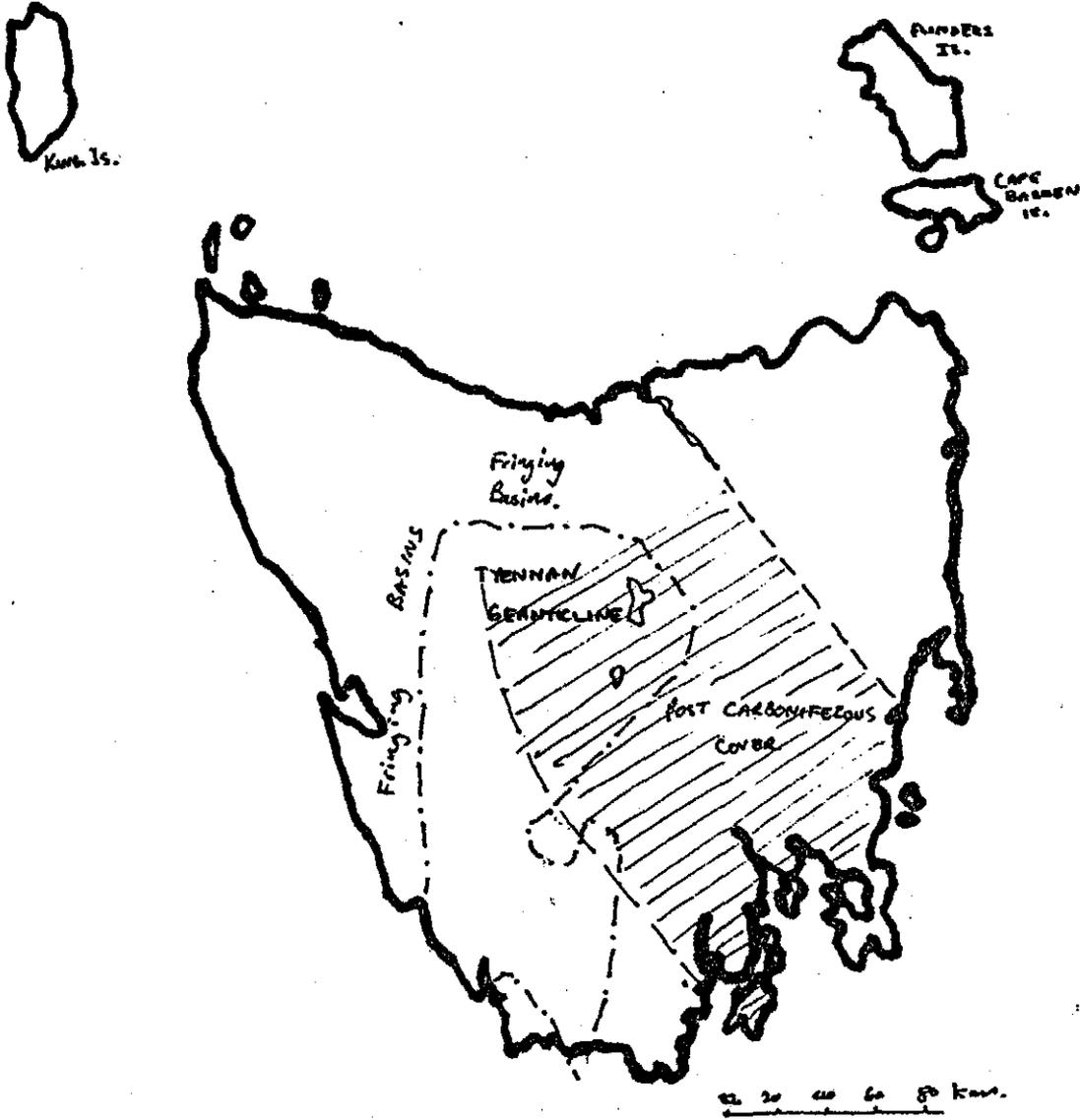
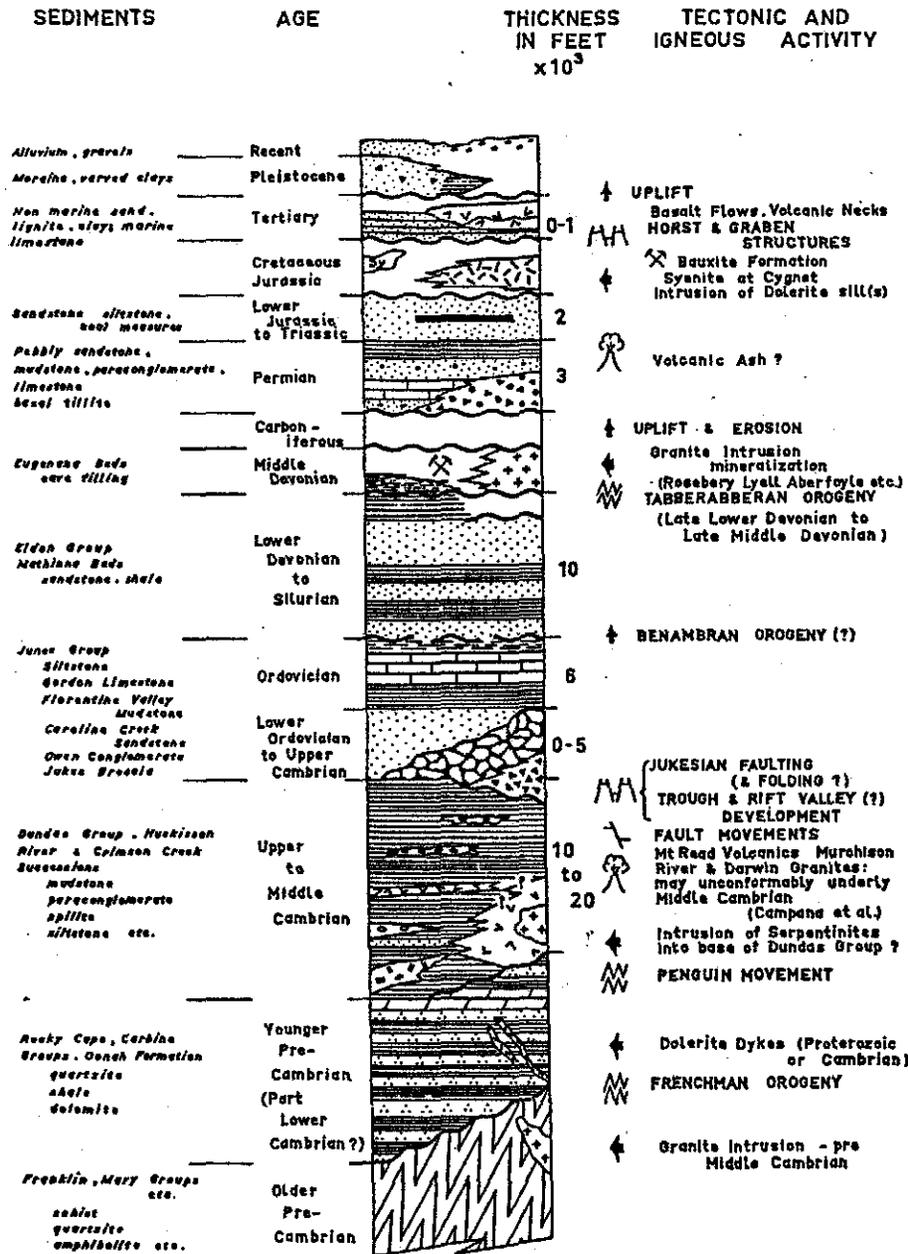


FIGURE 2.



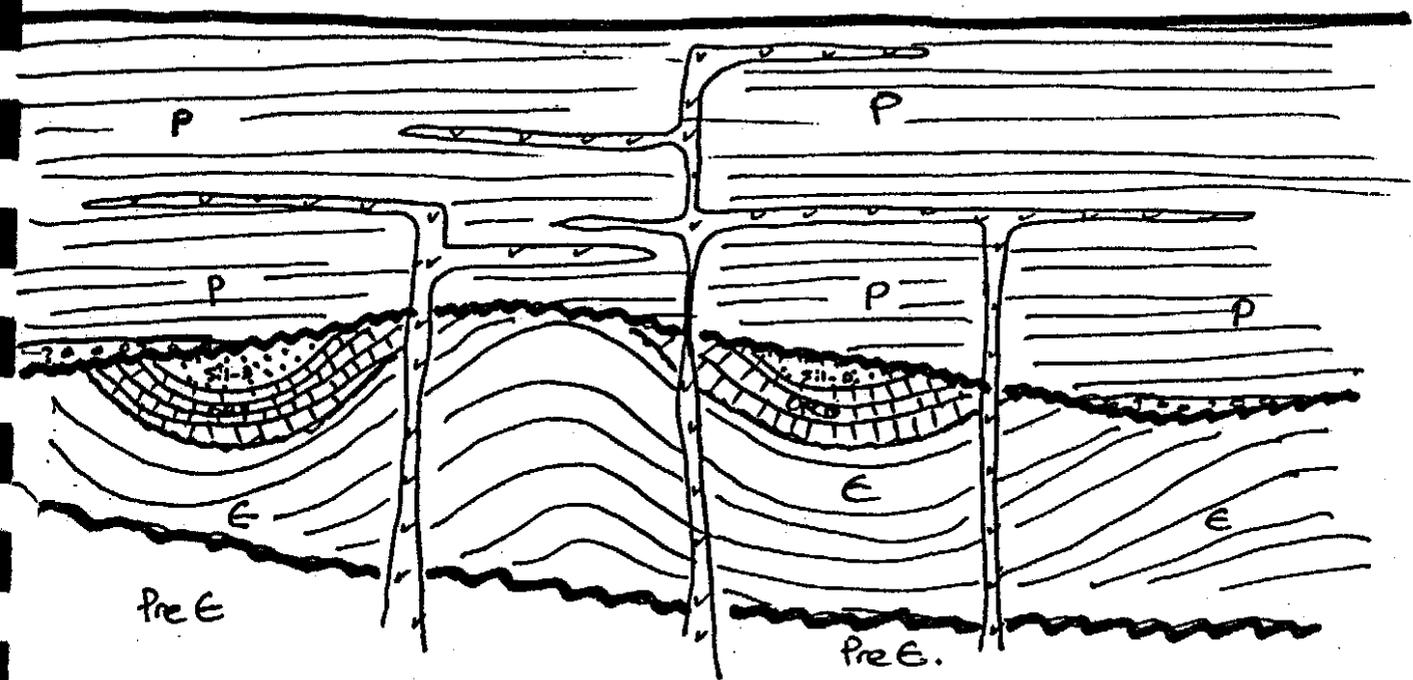
Geological column (Solomon).
Tasmania.

TABLE 1.

GENERALIZED STRATIGRAPHY

LITHOSTRATIGRAPHIC UNIT		LITHOLOGY	ECONOMIC CHARACTER	AGE
PARMEEVAN SUPERGROUP	UPPER 300M	Quartz Arenites Lithic Wackes	Suitable Seals ↑ ↓	TRIASSIC
	LOWER 300M	Coals Glacio-Marine Silts, Shales and Sandstones tillite		Possible Source rock (immature)
GORDON GROUP	ELDON GROUP 40M	Quartz Arenite	Possible Reservoir	UPPER ORD - LOWER SI
	PRECIPITOUS BLUFF BEDS 230M	Shales and Micrites	Possible Source Rock	UPPER ORDOVICIAN
	NEW RIVER BEDS 380M	Platform margin Calcarenite and Calcirudites	Possible Reservoir	UPPER MIDDLE ORDOVICIAN (BLACK RIVERAN)
	CASHIONS CREEK 150M	Algal Limestone	Possible Source Rocks ↑ ↓	LOWER MIDDLE ORDOVICIAN
	KARMBERG 100M	Nodular Limestone		
DENISON GROUP	Quartz Arenites		LOWER ORDOVICIAN	
		Turbidites		CAMBRIAN
		Dolomites Quartzites		PRE CAMBRIAN

TABLE 2



- Pre E Pre-Cambrian
- E Cambrian
- Grid Ordovician
Gordon Group Limestone
- Dotted Silurian - Eldon Group
- P Permian Parmeener Supergroup
- V Jurassic dolerite

Fig. 3: Diagrammatic Representation of Rock Relationships

FIGURE 3.

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REGIONAL GEOLOGY

Tasmanian geology is characterized by a basic two-fold subdivision into a region of Pre-Cambrian and Lower Palaeozoic rocks outcropping in Western Tasmania and a region of Lower to Mid Paleozoic rocks of contrasting facies which outcrop in north-eastern Tasmania. The boundary between these two blocks is obscured by an extensive cover of Permian sediments, extensive Jurassic dolerite intrusives and minor Tertiary basalt extrusives which extend over most of Central Tasmania - refer Fig. 2. Accordingly the nature of the Pre-Permian section in Central Tasmania is obscure, and there have been few deep stratigraphic tests to shed light on this question. EL 29/84 is located in south-eastern Tasmania, within the region characterized by Permian outcrop and dolerite intrusives.

Extensive folding occurred in the Devonian (Tabberaberran Orogeny) and there has been subsequent faulting and igneous activity in both the Jurassic and Late Cretaceous (?) - Early Tertiary.

STRATIGRAPHIC

The stratigraphic column for Tasmania is summarized in Table 1. The anticipated stratigraphy within the permit area is shown in Table 2. The rock-relationships are illustrated in Fig. 3.

PRE-CAMBRIAN

Pre-Cambrian rocks outcrop over about one-fifth of Tasmania, west of a line joining Hobart and Launceston, and may be divided into two main groups, viz.:

- (i) The regionally metamorphosed schists, quartzites, quartz schists, phyllites and slates commonly occurring in central west Tasmania, and
- (ii) The scarcely altered sandstones, quartzites, shales, slates, phyllites, dolomites and minor rudites more commonly developed in the north-west. The late Pre-Cambrian Penguin Movement is regarded as separating this section from the Cambrian.

CAMBRIAN

During the Middle Cambrian the Tyennan and West Cape geanticlines (Fig. 2) were emergent. Local intrusions of coarse conglomerates suggest intermittent uplift of the basin margins. Sediments consist of greywackes and siltstones regarded as representing a turbidite sequence, with associated volcanics. Tensional tectonics gave rise to horsts and grabens, with elongated basins forming on the flanks of the geanticlines.

ORDOVICIAN

Throughout most of Tasmania the Ordovician sequence rests unconformably on Pre-Cambrian or Cambrian rocks. A basal conglomeratic sequence is overlain by the marine Caroline Creek sandstone or its equivalents (up to 1000 ft.) and then by up to 5000 ft. of massive carbonates (Gordon Limestone). This unit is generally a relatively pure limestone, although argillaceous and arenaceous beds occur near the base and at the top of the sequence. The limestone has a bitumenous odour when struck, and tarry residues have been frequently noted. It consists predominantly of calcilutite with minor calcarenite and a few beds of calcirudite. Silolites are common: the presence of sulphides and bitumenous residues indicates deposition in a

DISTRIBUTION OF MIDDLE ORDOVICIAN, GORDON LIMESTONE.

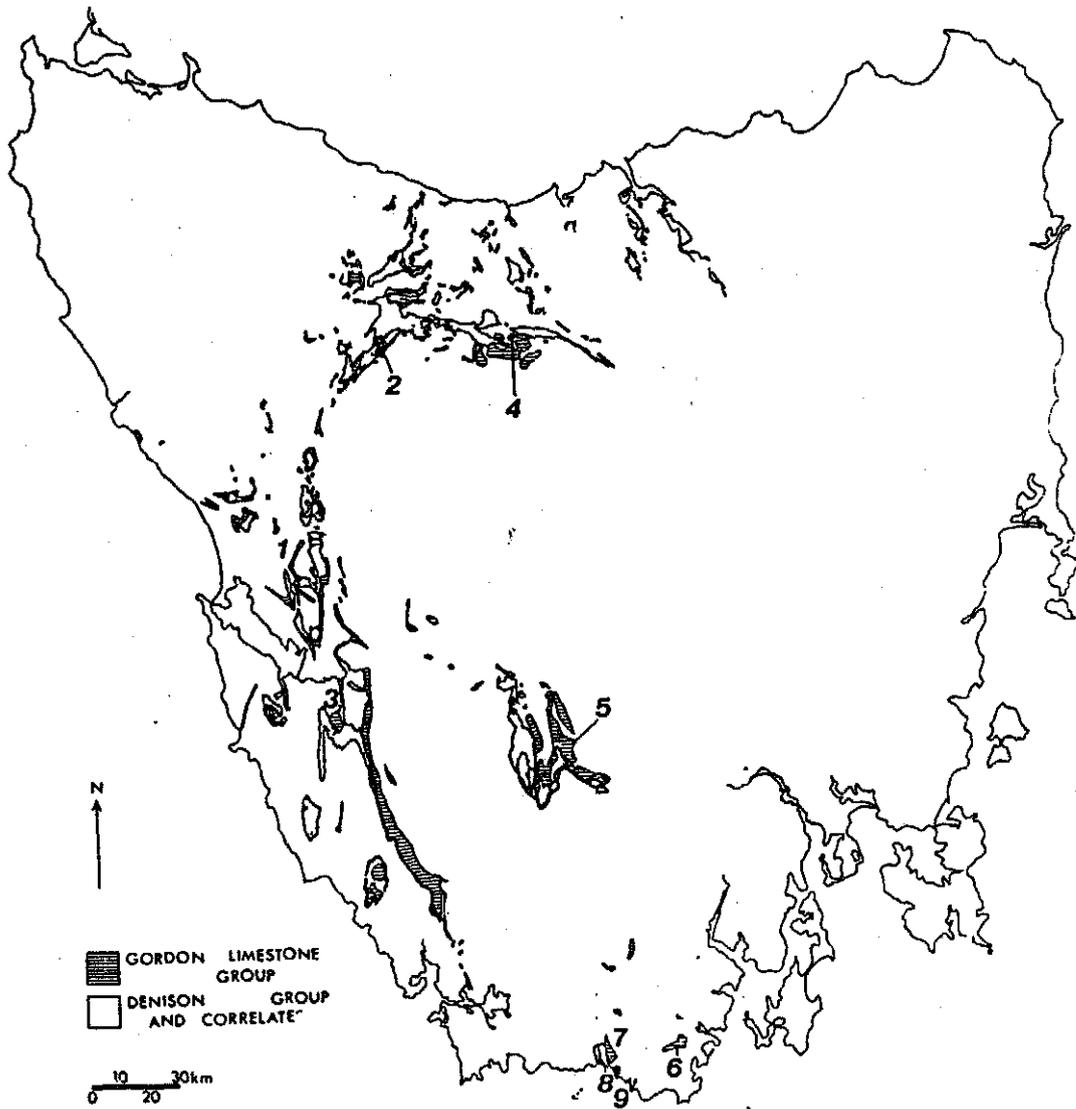


FIGURE 4.

LITHOFACIES MAP OF THE MIDDLE MIDDLE ORDOVICIAN (BLACKRIVERAN) BASED ON INFORMATION FROM ALL OUTCROPS.

A POSSIBLE DRILLING SITE IS INDICATED.

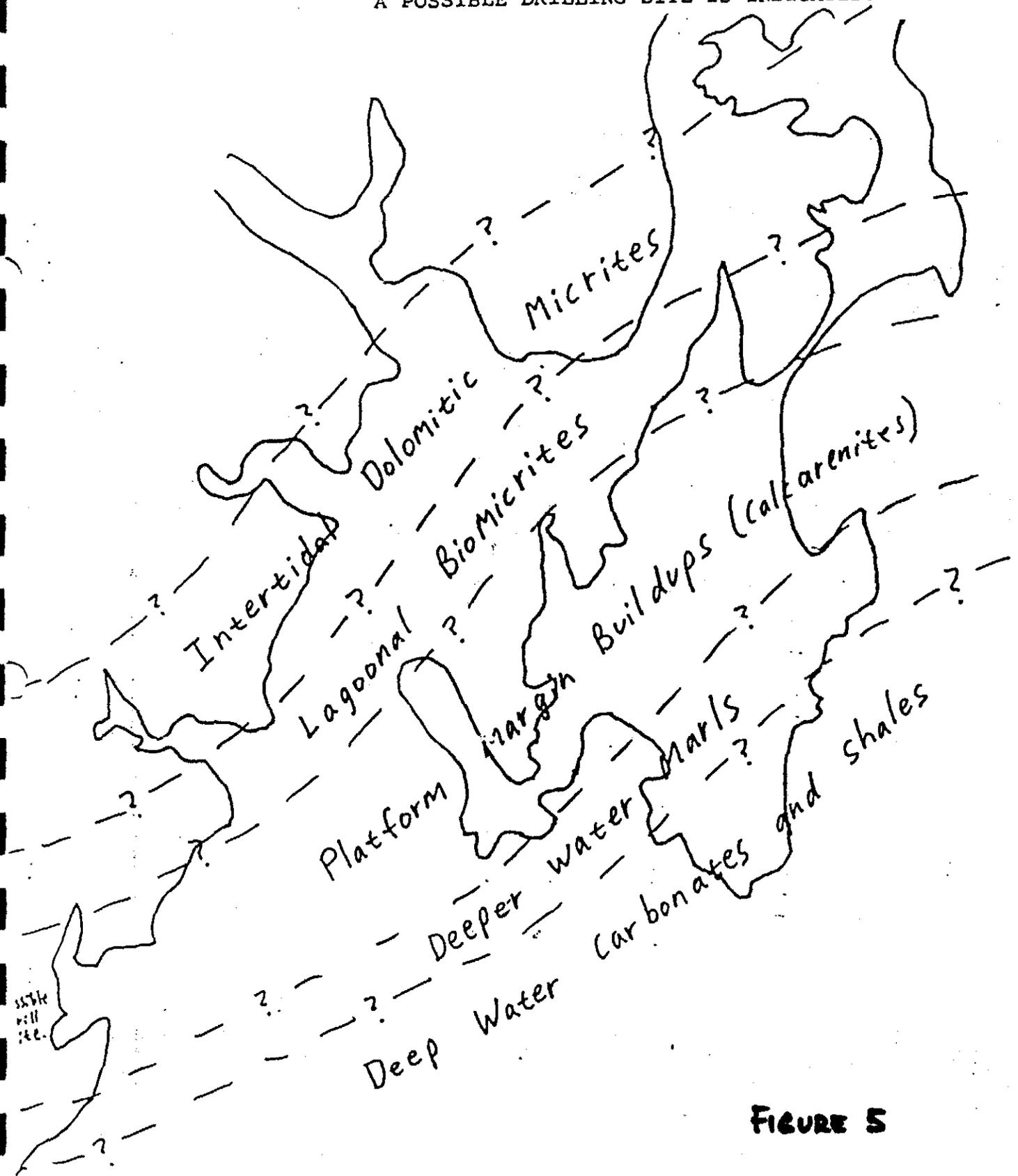
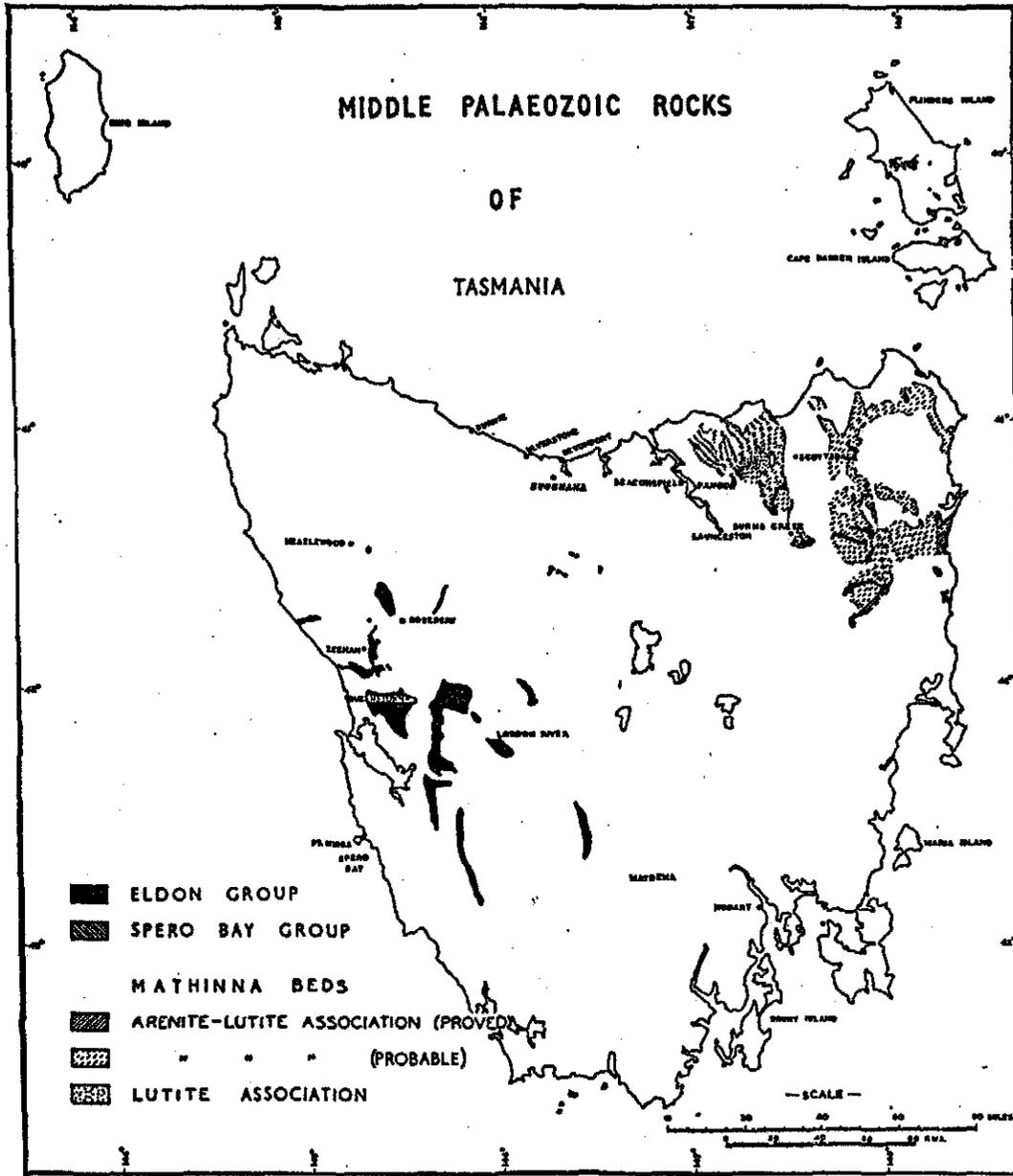


FIGURE 5

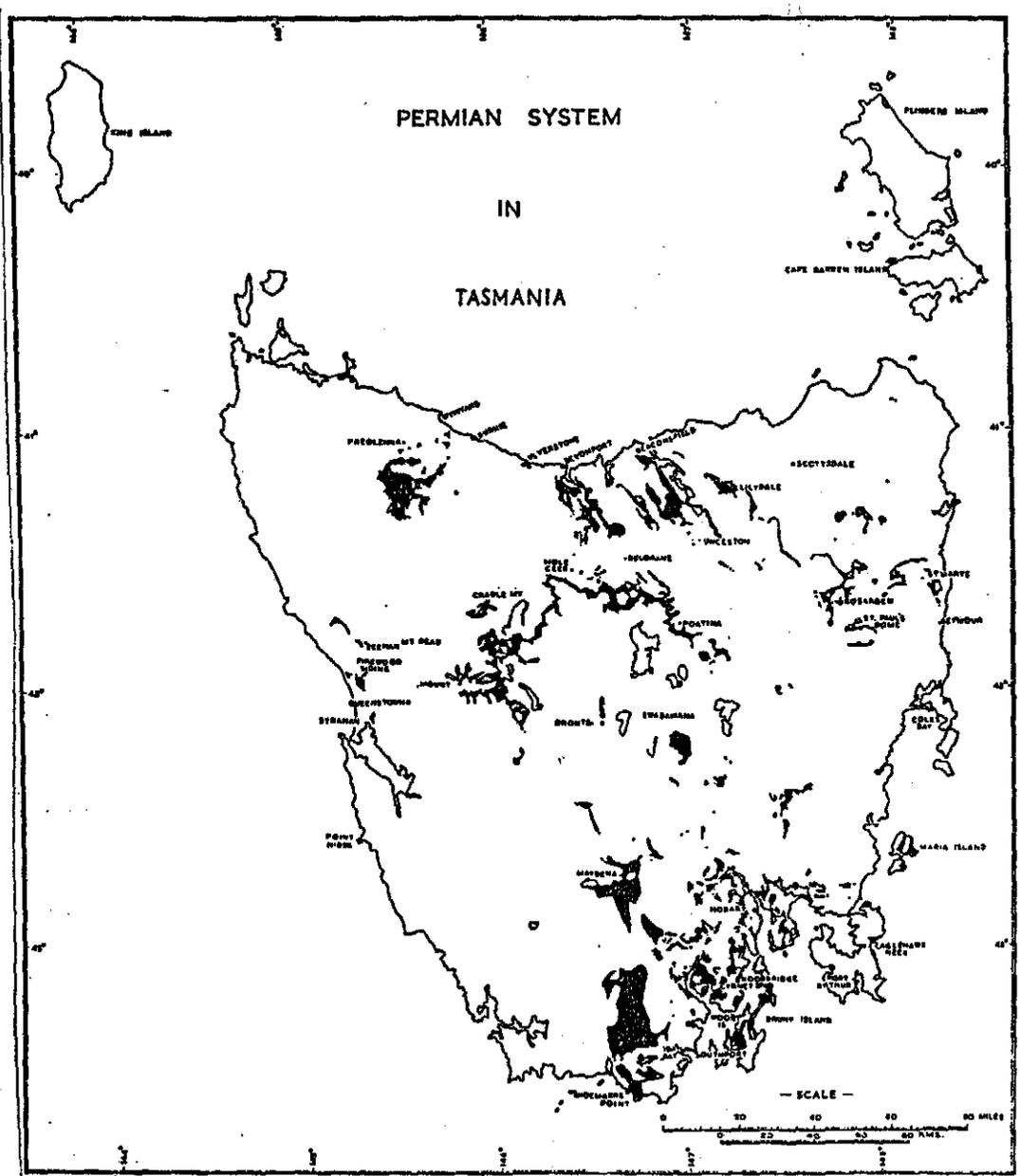


Distribution of Middle Palaeozoic rocks (Banks).

Eldon Group.

5 cm

FIGURE 6.



Distribution of the Permian System (Banks).

5 cm

FIGURE 7.

Correlation diagram of six lithostratigraphic columns through the lower part of the Parmeener Super-Group in south-east Tasmania

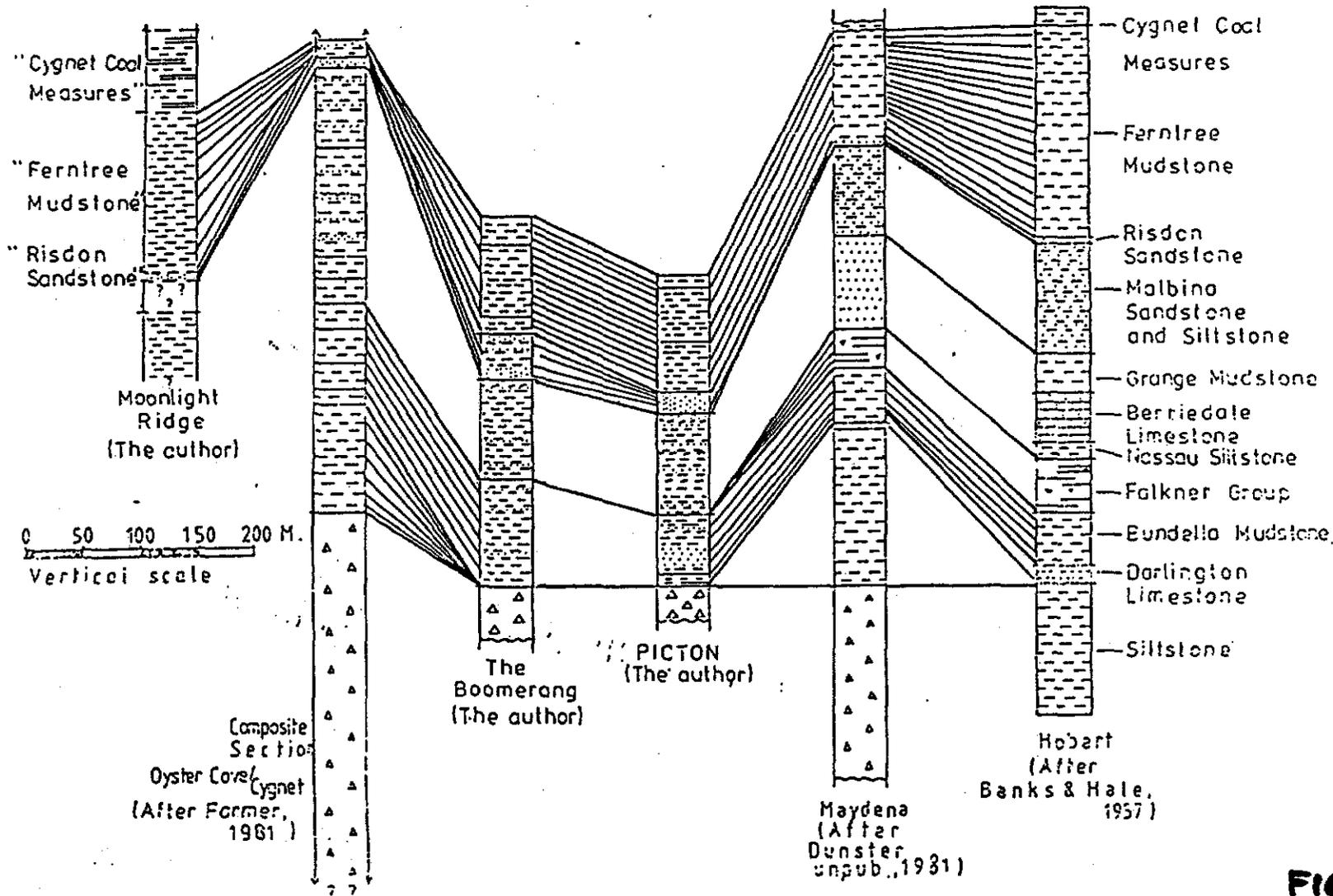


FIG. 8. STRATIGRAPHIC COLUMNS FOR THE LOWER PARMEENER SUPERGROUP. (UPPER CARBONIFEROUS - PERMIAN) SOUTH CENTRAL TASMANIA. FROM CORREY (1983).

FIGURE 8

891153

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FIG. 7. PALAEOGEOGRAPHIC MAP FOR PART OF THE
LOWER PERMIAN. FROM CLARKE (IN PRESS).

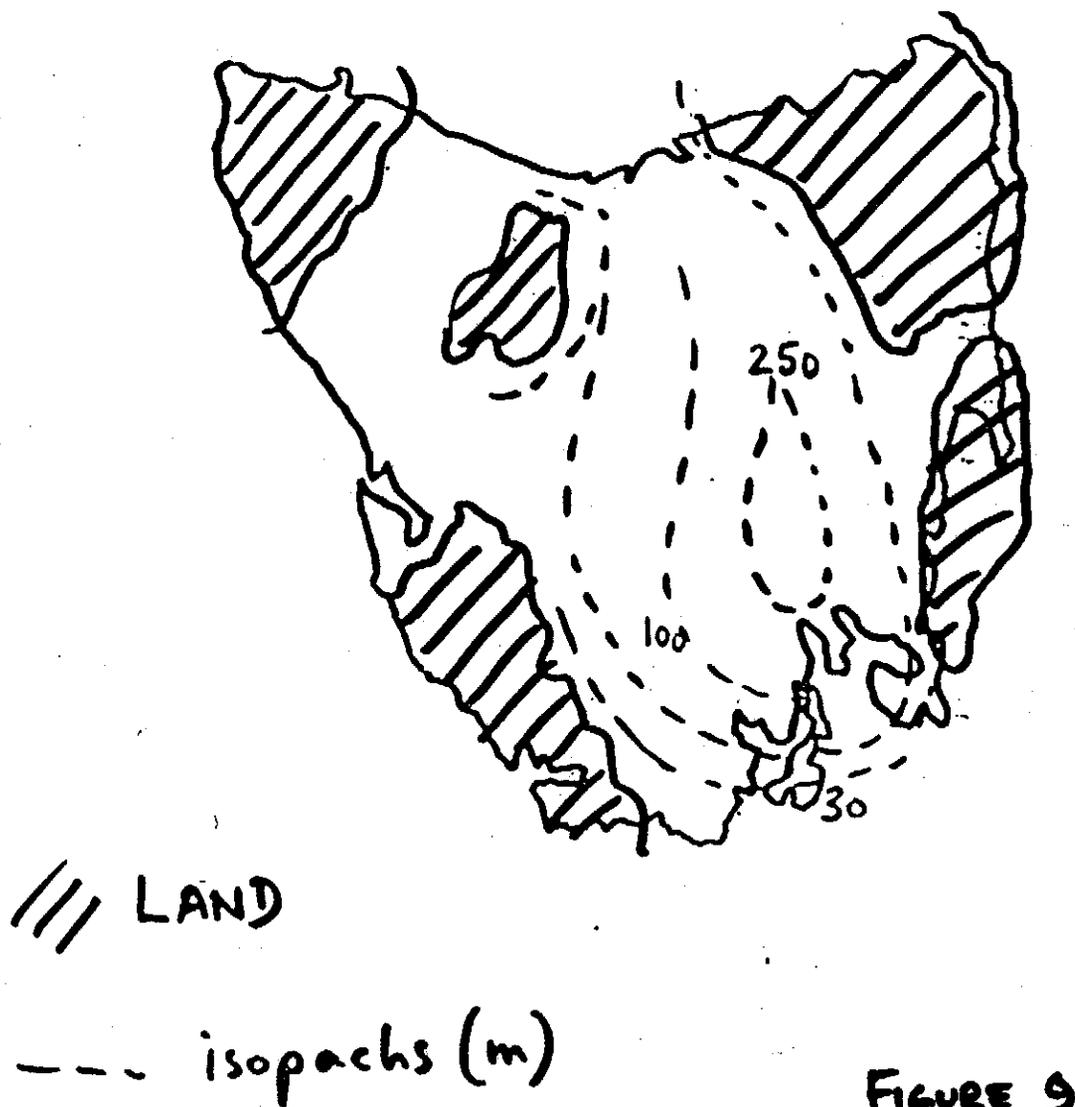


FIGURE 9

reducing environment. In outcrop the Gordon Limestone usually has a subdued topography, but occasionally karst topography is developed where there is sufficient relief above the water table. The outcrop map for Ordovician sediments in western Tasmania is included in Fig. 4. Burdell has constructed a lithofacies map for the Middle Ordovician carbonate sediments in south east Tasmania (Fig 5) based on the limited exposures available in that area. His model suggests a north-east south-west trending platform in this area, with deeper facies developing to the south east.

SILURIAN-DEVONIAN

Uplift of a source area in west or north-west Tasmania, possibly associated with the Benambran Orogeny, is believed to account for the change from carbonate to an arenaceous marine facies (Eldon Group sandstones). Deposition of marine sediments continued well into the Early Devonian before an orogenic event, (possibly the equivalent of the Tabberabberan Orogeny), caused extensive folding followed by erosion. The sequence rests with both conformity and disconformity on the Ordovician, and occupies the axial regions of synclines (refer Figs. 3, 14 and 15).

In outcrop the Eldon Group consists of a basal, poorly sorted, cross-bedded, fossiliferous quartzite (Crotty Quartzite) up to 1600' thick, overlain by several hundred feet of fine grained sediments, then around 200' of quartzite followed by a sequence of siltstone, sandstone and shale. Apart from the basal conglomeratic member this formation is characterized by a distinct oscillation between sand and silt facies, which is believed to reflect the effect of tectonic movements on these shelf-type deposits. The Eldon Group outcrop distribution is drawn in Fig. 6.

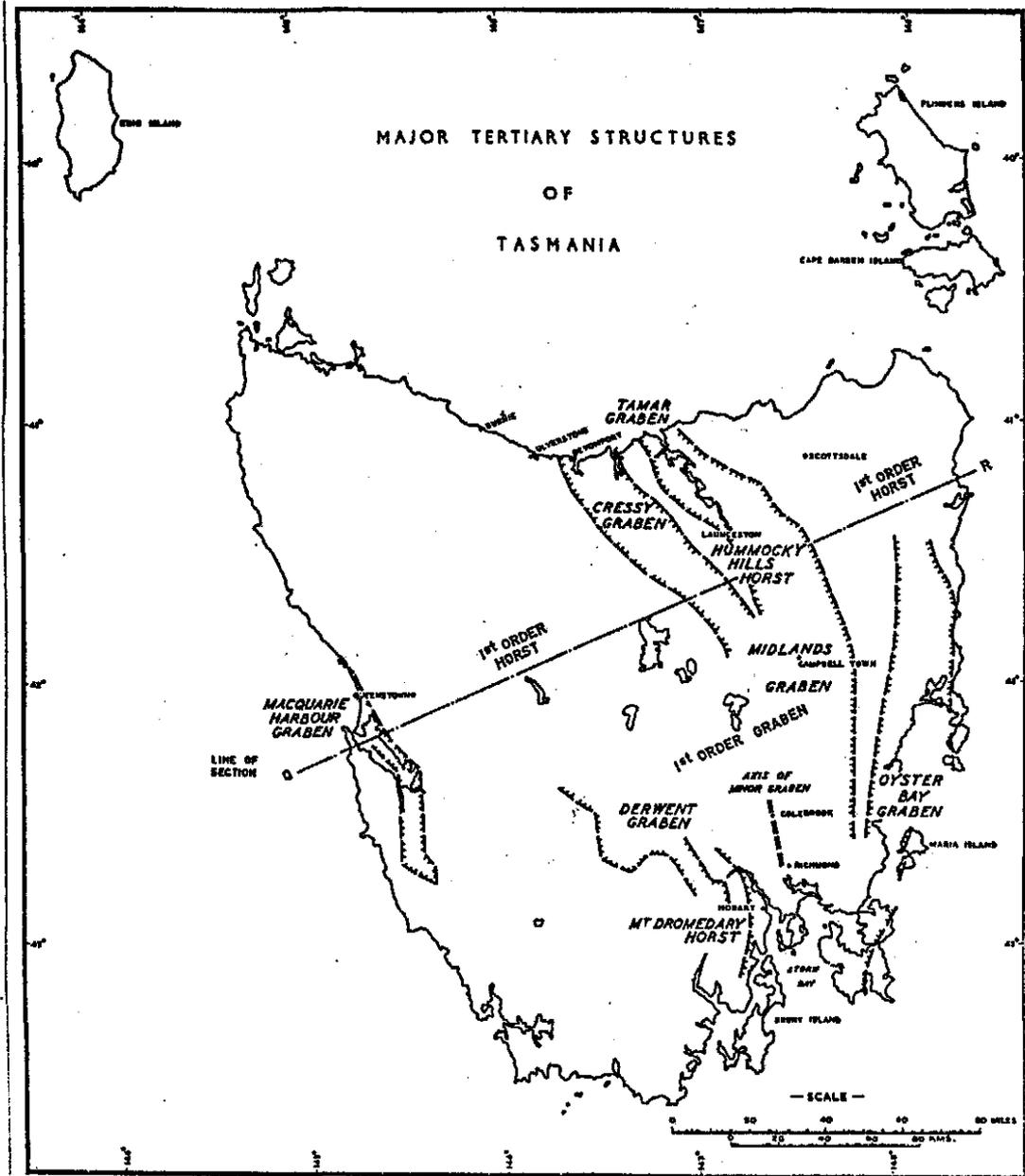
Devonian uplift and erosion removed much of the Siluro-Devonian sequence (estimated at up to 3000').

PERMO-TRIASSIC

Early Permian glaciation ensued with associated Tillite deposition, then several thousand feet of siltstone, sandstone and limestone comprising two cycles of marine sediments separating three freshwater sequences. The succeeding Triassic rocks are entirely fresh-water, consisting of sandstones, siltstones and coal measures. The oil shales found in the Permian of Northern Tasmania are not present in Southern Tasmania. The considerable variations in thickness and facies of basal Permian units suggest high relief on the pre-Permian unconformity (refer Fig. 3). Younger Permian units are more uniform in thickness and facies, being considerably easier to correlate. The Permo-Triassic sequence is known as the 'Parmeener Supergroup' and is widespread throughout Tasmania as shown in Fig. 7. Burdell considers the permit area was "near to the western depositional margin of the Tasman Basin during the Permian (refer Fig. 9). As a result many of the units recognized in the basin depocentre (north of Hobart) are either thinner or absent in this area". The stratigraphic relations established from outcrops, in South Central Tasmania are shown in Fig. 8 and the Permian palaeogeography is illustrated in Fig. 9. In the Late Triassic or Early Jurassic deposition ceased, to be followed by the intrusion of large sheets of dolerite, with accompanying normal faulting on a NNW trend.

TERTIARY

Tertiary marine sediments occur as a discontinuous fringe around north-western Tasmania and Flinders Island, and emerged beaches and shell-beds



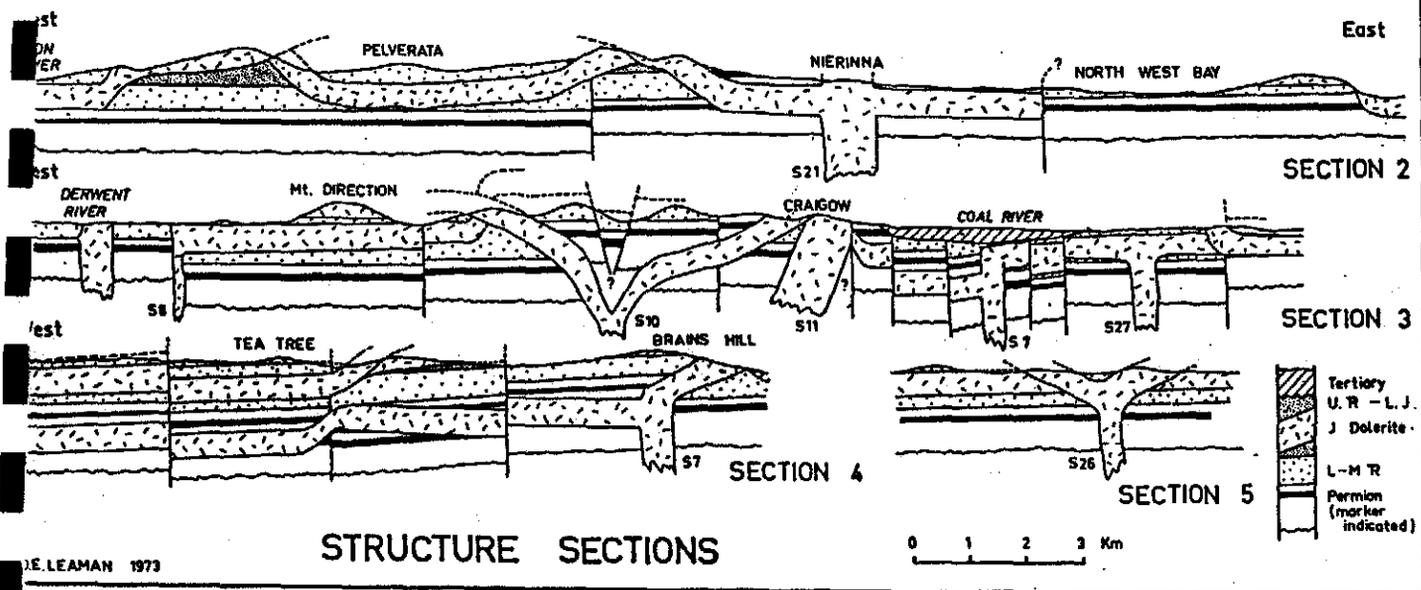
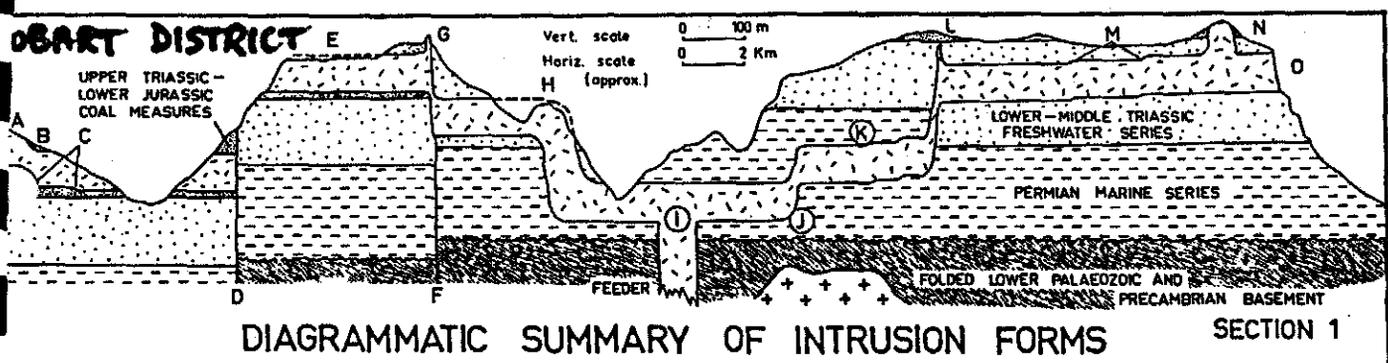
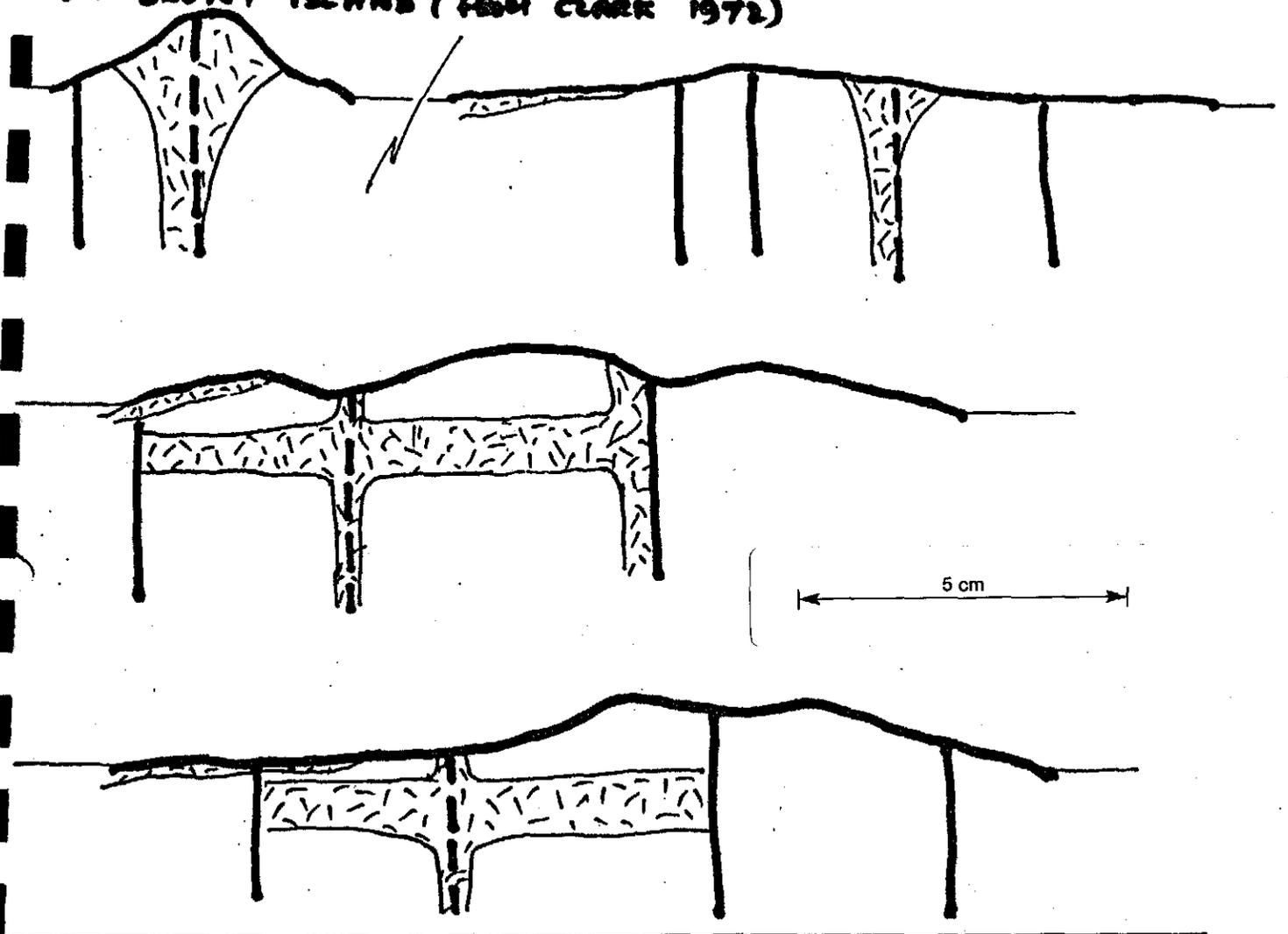
Major Tertiary structures (Banks).

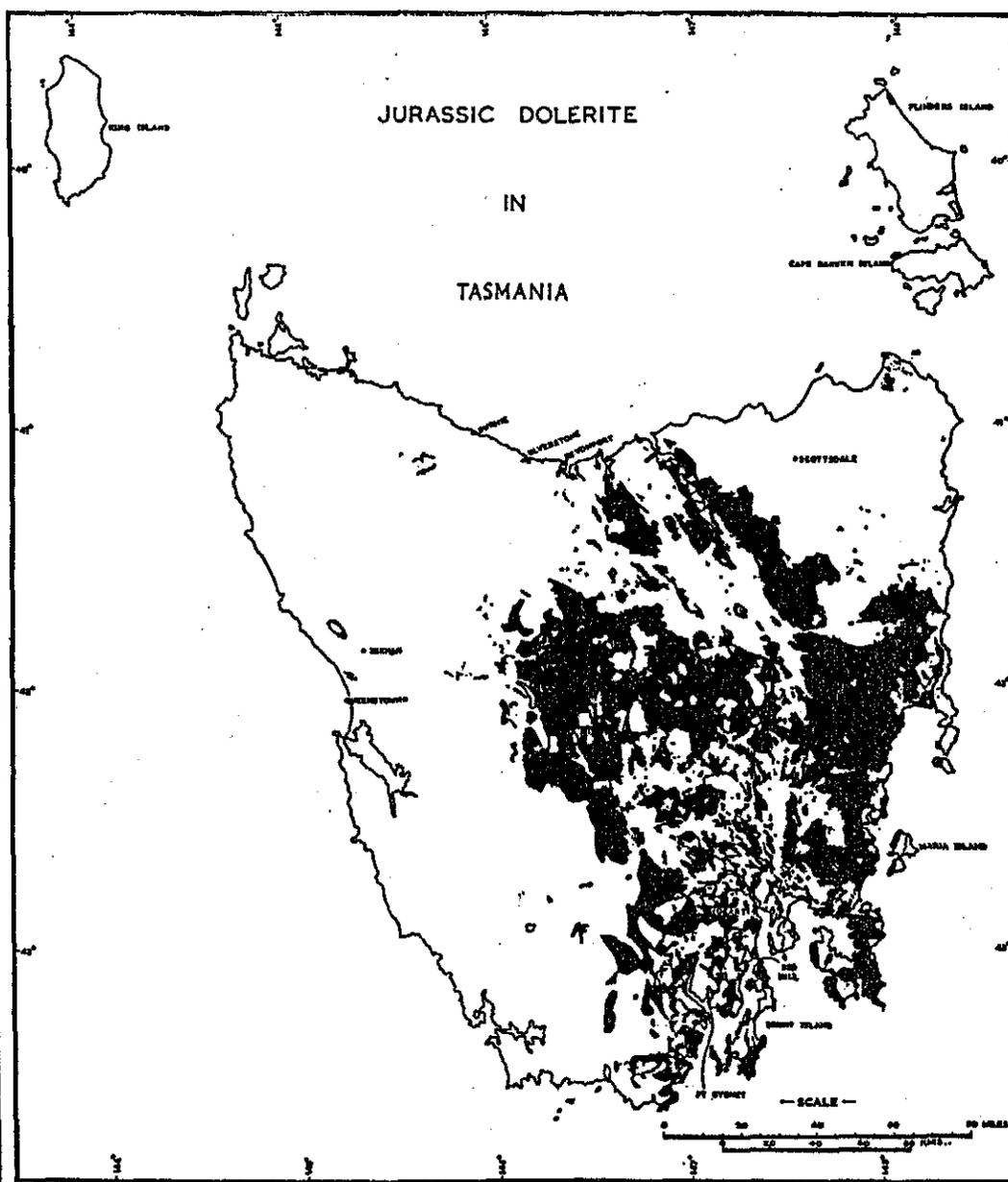
5 cm

FIGURE 10

EXTENT AND FORM OF DOLERITE (DIABASE) INTRUSIONS ON BRUNY ISLAND (FROM CLARK 1972)

891157

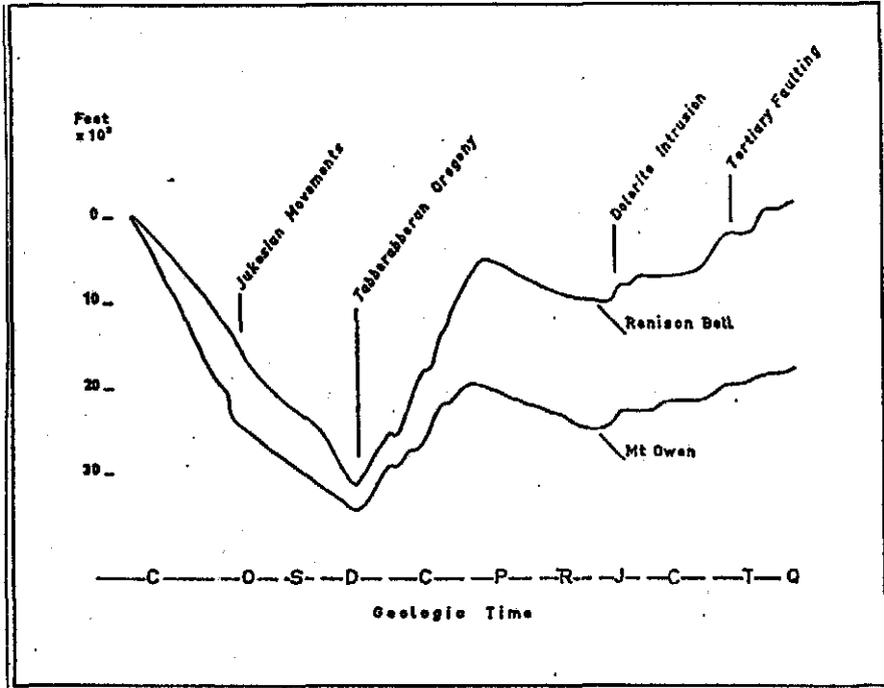




Distribution of Jurassic dolerite (Spry).

5 cm

FIGURE 12



Vertical movements on a datum horizon (Renison Bell Sandstone) from Cambrian to Recent (Solomon).

from Geology of Tasmania, G.S.A.

FIGURE 13

are common in coastal areas. Non-marine Tertiary sediments were deposited in Tertiary grabens associated with normal faulting on north to north west trends, as shown in Fig. 10.

IGNEOUS ROCKS

Large scale intrusions of dolerite occurred during a relatively short period in the Middle Jurassic; several thousand cubic miles of magma "formed a nearly continuous body through the Permian and Triassic sediments over almost all of the island". The dolerite occurs in a variety of forms (Fig. 11), most commonly as sills, but in some places as steep sided dykes. Dolerite now caps most of the highest mountains and underlies the Great Central Plateau (Fig. 12). Up to three dolerite sills within the Permo-Triassic section have been observed in the general permit area, the lowest being located on or near the pre-Permian unconformity.

Stocks of porphyritic syenite and a radial dyke system of various alkaline intermediate porphyries occur at Pt. Cygnet, to the west of Bruny Island, and are thought to be of Cretaceous age (100 mybp). Tertiary basalt flows are common throughout Tasmania, but are mostly confined to pre-existing river and stream valleys. They are not recorded at Bruny Island.

STRUCTURE

The basement structural elements are illustrated in Fig. 2. It is probable that the Tyennan Geanticline became emergent in the early Pre-Cambrian and sourced restricted sedimentation. The Middle or Late Proterozoic Penguin movement is believed to have caused extensive erosion but apparently did not involve widespread folding.

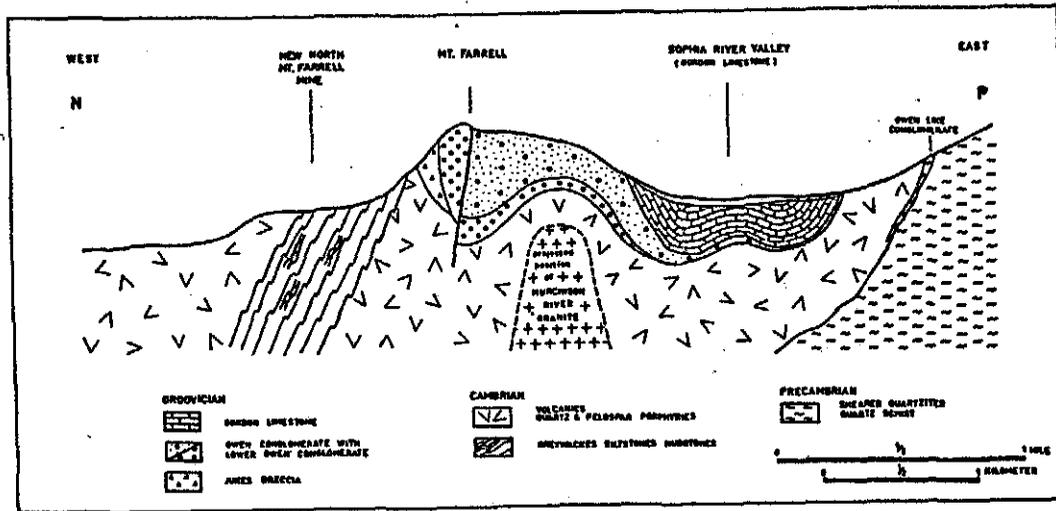
During the Middle Cambrian the Tyennan and West Cape Geanticlines were emergent: local intrusions of coarse conglomerates suggest intermittent uplift of the basin margins. The overall structural style is tensional, (horst-graben), with elongated basins forming on the flanks of the geanticlines. "These basins subsided independently and erratically, and were filled by a suite of volcanics and sediments exhibiting ... rapid lithological variations. This phase of unstable 'tectonic' sedimentation represents a marked change from Pre-Cambrian conditions; it was accompanied by considerable volcanic and intrusive igneous activity (serpentinites)".

Relative tectonic movements from the Cambrian to Recent are illustrated in Fig. 13.

The Ordovician Jukesian movement accentuated the horst-graben type tectonics, and initial conglomeratic sedimentation was followed by deposition of carbonates (Gordon Limestone). Deposition continued from the Ordovician until the Devonian; the Siluro-Devonian sequence was probably far more extensive than the graben-basins characterizing the Cambrian and Early Ordovician. The marine clastics of the Eldon Group are considered to have exceeded 10000' in thickness.

The ensuing Devonian Tabberabberan Orogeny caused major uplift and deformation along dominantly NW or NNW trends followed by extensive erosion. The 'younger' sediments (Ordovician and Silurian) are thus preserved only in the cores of eroded synclines, whilst the Cambrian, although less extensive originally, is more extensively preserved. Deposition did not resume until the Permian or possibly the Late Carboniferous. The resultant erosional surface prior to Permian deposition was characterized by extensive relief, and in south-eastern Tasmania may have looked similar to that shown in Fig. 4, which represents an east-west section at Mt. Farrell

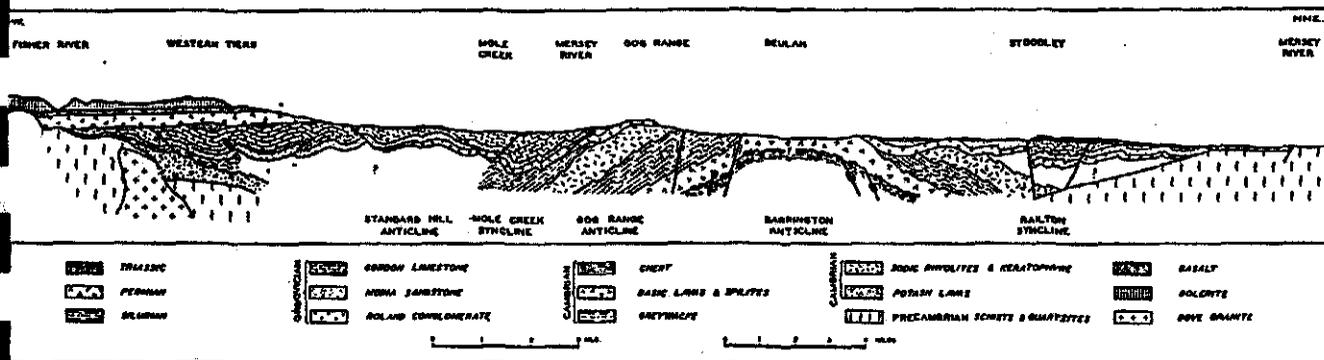
160



Section through Tullah (Solomon and Brooks). (Mt Farrell)

FIGURE 14.

5 cm



Section through the North-West Coast (I. B. Jennings).

FIGURE 15.

(western Tasmania), although at Bruny Island the section may possibly more closely resemble the south western end of Fig 15, a section through the North-West coast.

One of the most spectacular features of Tasmanian geology is the angular unconformity at the base of the Permian. Permo-Triassic sediments above the unconformity are sub-horizontal, (the unconformity dips at around 5-10 degrees due to Tertiary epeirogenic movements), and overlie folded and eroded Older Palaeozoic rocks. As Figs. 13 and 14 illustrate, the Lower Palaeozoic subcrop is likely to be erratic, and in the absence of well-control, geophysical investigations provide the only feasible means of predicting its occurrence.

From the Permian to the present tectonic activity consisted mainly of gravity faulting and concomitant hypabyssal intrusion and volcanism; sedimentation, both marine and terrestrial, was relatively thin.

The most significant movements were probably Early Tertiary: evidence for Recent activity is provided by earthquakes and displacement of drainage systems. " Raised shore platforms and rejuvenated rivers suggest recent uplift for much of Tasmania, but this was locally preceded by partial drowning, which produced a highly indented coastline in the south and development of several 'upstream' deltas.

PREVIOUS EXPLORATION

Geophysical

The accompanying review of pre-1987 geophysical data was prepared by Dr. David Leaman for Conga Oil in February of this year, and fully summarizes the extent and significance of previous geophysical exploration, together with recommendations for future activity (now under way). (Refer Appendix 1.)

PREVIOUS EXPLORATIONGeological

In 1909 the Government Geologist (W. H. Twelvetrees) investigated oil seeps and shows along the south coast of Tasmania.

In 1915 Dr. A. Wade discussed the significance of these seeps in Parliamentary Paper No. 60, 'Report on the Prospects of Discovering Petroleum on North Bruny Island, Tasmania'.

Subsequently little happened in this area until BHP compiled a geological map based on rapid helicopter reconnaissance. Unpublished theses of University of Tasmania students dealing with this area include Davidson (1969), Rigg (1970), Clarke (1972), Coney (1983), and Farmer (1985). Burrett et al initiated studies concentrated mainly on the Ordovician limestone sequence (Burrett et al 1981, 82, 84), including conodont studies aimed at determining the level of organic maturation. Sampling of the Johnson Well seep was undertaken in 1986 by Bendall.

The North Bruny Island area is now mapped at a scale of 1:50,000. (Kingborough Sheet Geological Survey, Tasmania, published 1981).

Mines Department coreholes at Glenorchy and Woodbridge have also been significant in establishing the nature of the pre-Permian section in the vicinity of Hobart.

Previous petroleum exploration efforts onshore in Tasmania have concentrated on the Permo-Triassic section (Parameener Supergroup), particularly focussing on the significance of Early Permian oil-shales. By contrast the pre-Permian sequence was neglected until data on the organic maturity levels of the Gordon Group indicated that these sediments lay in the oil window, (the significance of oil seeps at North Bruny will be discussed below).

CHART OF ORGANIC MATURATION

891164

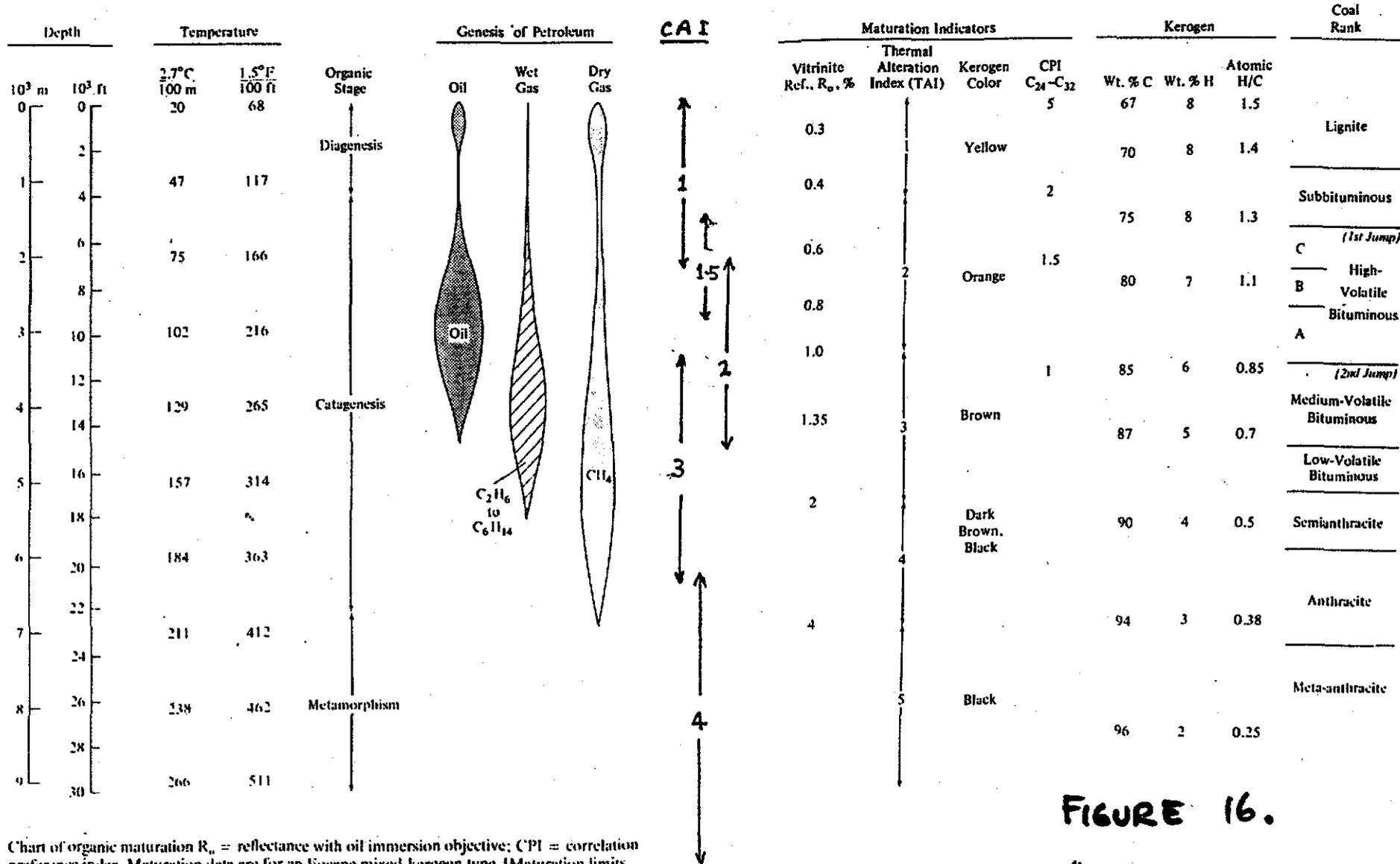


FIGURE 16.

(Hunt)

Chart of organic maturation R_v = reflectance with oil immersion objective; CPI = correlation preference index. Maturation data are for an Eocene mixed-kerogen type. [Maturation limits from Dow 1977a; Staplin 1969; Teichmüller 1974]

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CONODONT COLOUR ALTERATION INDEX
FOR ALL ORDOVICIAN CARBONATE
OCCURRENCES. HIGH VALUES IN THE
WEST ARE DUE TO PROXIMITY TO A
DOLERITE FEEDER DYKE.
BURRETT (UNPUBLISHED).

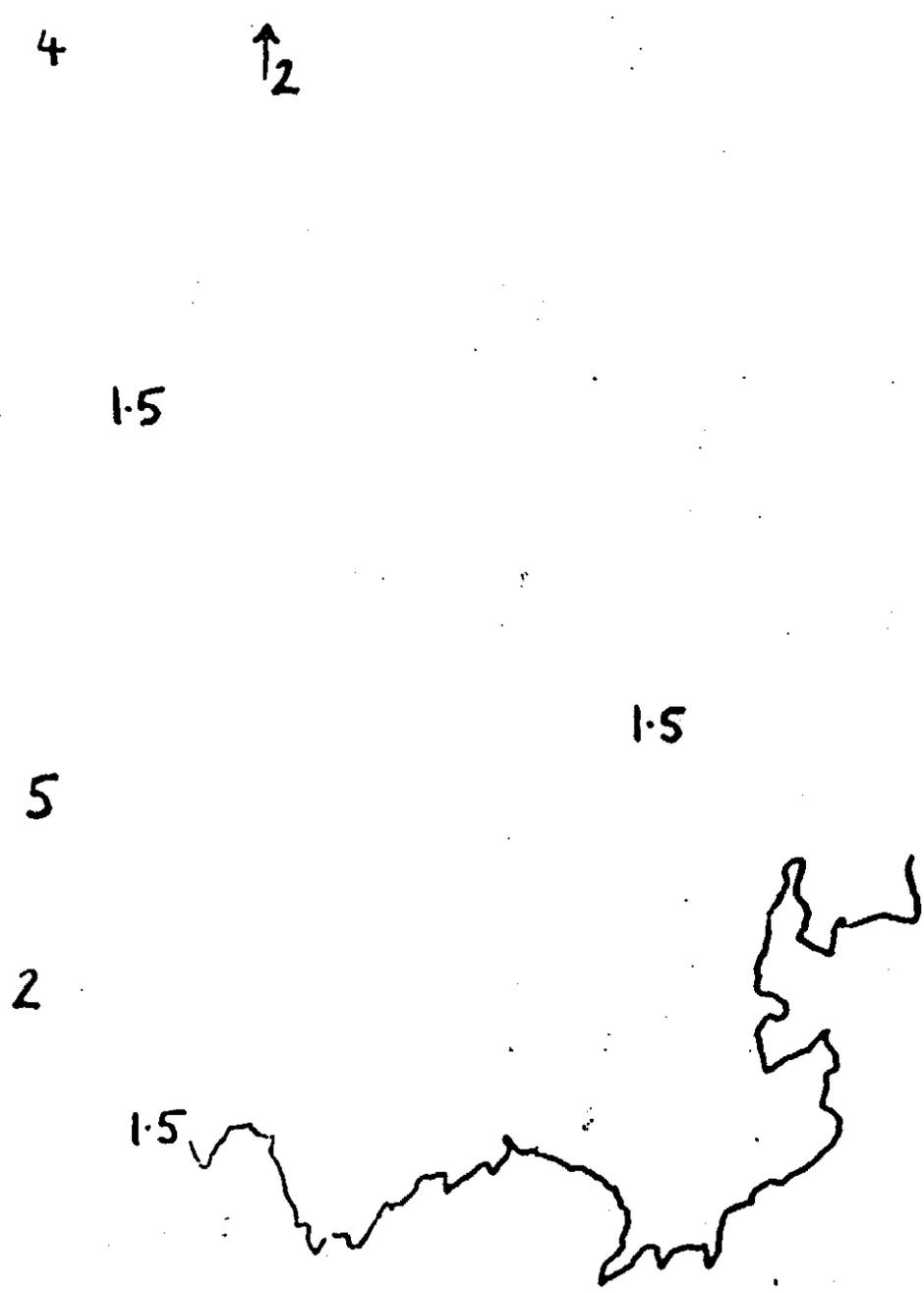


FIGURE 17

C. 165
7.
SOURCE/MATURATION

Permian shales of the Parmeener Supergroup are regarded as too immature to act as effective sources for hydrocarbon generation; the Permian oil-shales noted in Northern Tasmania do not occur south of Bicheno. Conodont Colour Alteration Index measurements (CAI) for carbonates of the Gordon Limestone suggest that this unit is a potential source in southern Tasmania; the presence of bitumens in Gordon Limestone outcrops is also regarded as significant.

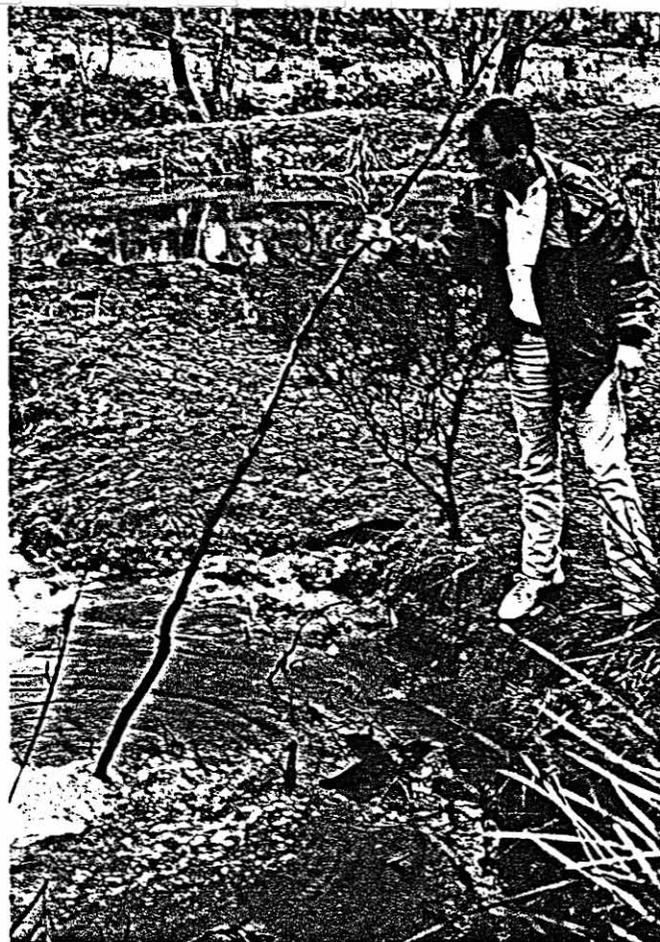
The question arises as to what evidence exists for the present of Gordon Limestone subcrop at Bruny Island. As the area is now covered by Permian sediments, dolerite and beach or beach-derived deposits the evidence for the nature of the pre-Permian section at North Bruny relies on:

1. Analogy with the known pre-Permian geology of south Tasmania, i.e. relatively tight elongated folds of Lower Palaeozoics which have been eroded as in Western Tasmania, or folded Lower Palaeozoic rocks with deepwater facies as in north-east Tasmania.
2. Evidence from Mines Department boreholes in the Hobart region at Glenorchy and Woodbridge have established pre-Permian sections similar to Western Tasmanian outcrops located approximately 50 km to the west, suggesting this is the most likely style for the pre-Permian basement in the D'Entrecasteaux Channel region, including North Bruny Island.
3. Geophysical Data: Leaman's review of the geophysics spells out in detail his arguments for the presence of Silurian, Ordovician and Cambrian rocks in the subsurface, based on analysis of magnetic and gravity data.
4. Seeps at Bruny Island. The presence of oil seeps at North Bruny Island suggests the present of source rocks: in the absence of potential Permian source rocks the most plausible explanation would appear to be sourcing from an Early Palaeozoic sequence, most likely the Gordon Limestone.

Although no systematic source sampling of the Gordon Limestone has been undertaken to date, particularly with respect to total organic carbon content (TOC), the thermal maturity studies carried out by Dr. Burrett utilizing conodont colour alteration index (CAI) values, (Fig. 16), indicate that the Ordovician section in Southern Tasmania lies within the oil generation window. (Note: the oil generation window corresponds to CAI values of 1.5 - 2). The areal distribution and range of these values is illustrated in Fig. 17.

In view of the significant faulting associated with the Jurassic dolerite intrusions the timing of generation is critical for preservation of any hydrocarbons produced. Relatively high temperature gradients and heat flows have been measured in Tasmania although no deep well values are available in Southern Tasmania. A heat flow value of 87 mw/sq.m was recorded at the Glenorchy borehole. Leaman suggests that higher heat flows are associated with old geosynclines or granite rather than metamorphic basement.

He also considers that oil generation probably commenced as the result of a Late Cretaceous or possible Early Triassic thermal event. Burrett's CAI data also indicates that local heating associated with intrusion of magma would have been sufficient to move any source material present into the oil and/or gas window, but probably on a very restricted scale.



JOHNSON'S WELL SEEP

FIGURE 18

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891167

SEAL

The low energy sediments (mudstone, siltstone), of the Permian and the dolerite intrusions themselves offer excellent seals assuming that the Jurassic faults are now not acting as migration paths. Note that these seals would not have been effective until after Jurassic orogenic activity had ceased.

HYDROCARBON SHOWS

Hydrocarbon shows in the permit area are restricted to the occurrence of hydrocarbon seeps which have been reported in Southern Tasmania and particularly at North Bruny Island since the turn of the century. The location and exact nature of these seeps has proved difficult to determine, and should be carefully investigated as an essential part of the on-going exploration (see Recommendations).

The best known of these seeps occurs at Johnsons Well (Fig. 18), where a sample from the edge of the seep was analyzed by ANALABS (Appendix I).

The source of this seep is conjectural: the nature of the hydrocarbon distribution suggests it is likely to have been generated from a carbonate sequence, but the evidence is not conclusive. The possibility of local heating of Permian sediments (associated with the intrusion of dolerite) releasing hydrocarbons cannot be discounted.

Leaman has pointed out that migration from source to seep may well be tortuous, and has suggested two possible mechanisms (Fig. 19) based on different pre-Permian structuring possibilities.

Obvious migration paths are provided by the pre-Permian unconformity and faults.

RESERVOIR

Burrett identified at least three possible source rocks:

- (i) Basal sediments of the Permian Parmeener Supergroup. (Although the basal Permian is generally of low energy facies, and more suited as a seal, it is possible that localized conglomerates on the unconformity may be eligible.
- (ii) Eldon Group sandstones underlying the unconformity (with possible epidiagenetic enhancement of reservoir quality).
- (iii) Calcarenitic upper parts of the Ordovician limestones.

Some thin-section studies have been carried out on these units, but definitive sub-surface core samples and well-logs will be required before making any further estimates of their reservoir potential.

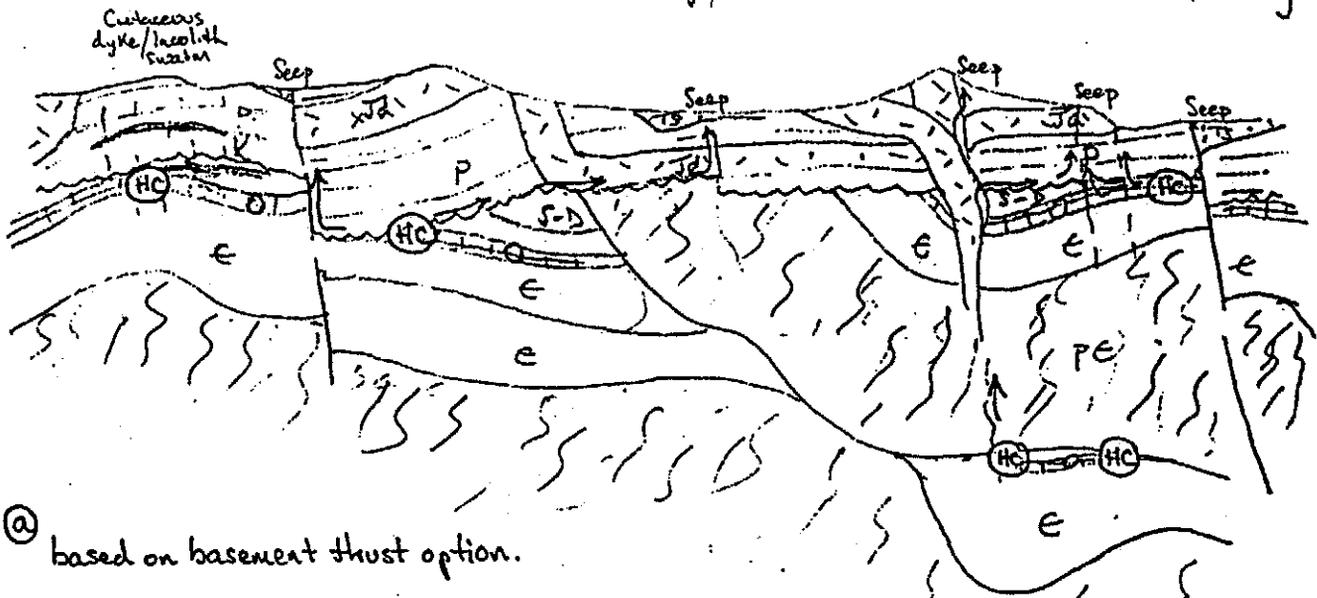
ENTRAPMENT

Leaman considers there are two possible structural styles for the Lower Palaeozoic section in the permit area, viz. plunging folds or overthrust blocks, Fig. 19. A variety of possible trap types can be

Cygnets dome

Woodbridge/Channel

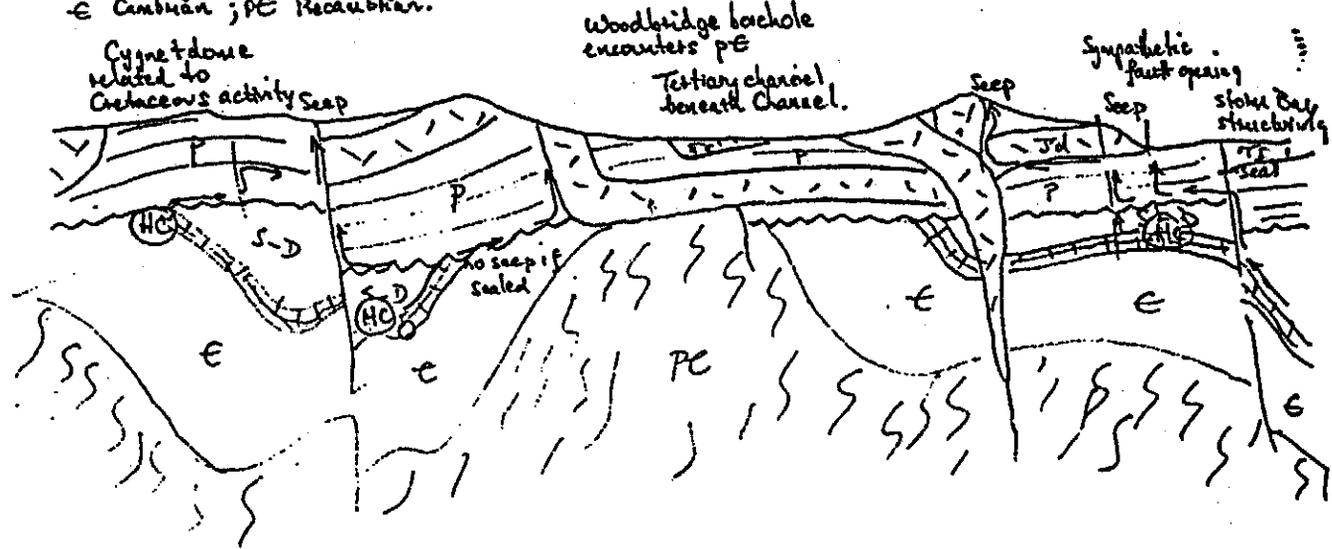
Storm Bay



(a) based on basement thrust option.

Note ways in which Permian unconformity might be used in migration paths. Bruy seeps may be related to sympathetic opening of old fractures parallel to Storm Bay movements. No great displacement implied. Note also that some reservoirs/structures could exist and not leak due to various types of seal and no later fracturing.

T Tertiary sediment; C Cretaceous; Jd Jurassic dolerite; P Permian; S-D Siluro-Devonian; O Ordovician; E Cambrian; PE Precambrian.



(b) based on plunging basement anticline option.

South of Woodbridge the anticline could contain other Paleozoic rocks and if eroded could contain traps in its own right. Alternatively its interaction, with source or reservoirs, with the Permian unconformity could lead to very dispersed migration paths.

WARNING: Diagrams not to scale and not intended to portray probable structures at any level. These will not be known until exploration and interpretation is much more advanced. Diagrams only suggest how seeps might arise.

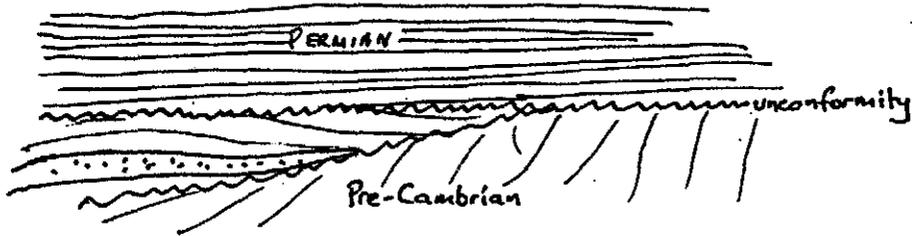
DIAGRAMMATIC PRESENTATION OF ROCK RELATIONSHIPS AND RELATIONSHIP TO SEEPS.

from Leaman 1987.

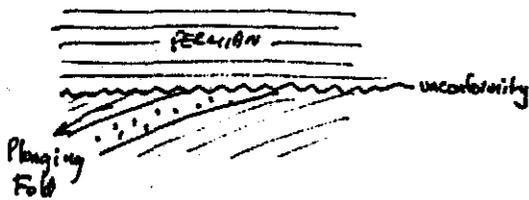
FIGURE 19

envisaged which are consistent with these structural pictures. Some of these are illustrated below.

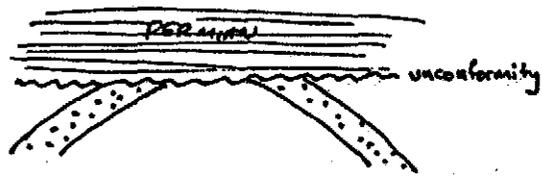
- 1) Stratigraphic Traps where post-Cambrian units onlap basement and are sealed by overlying Permian sediments and/or dolerites.



- 2) Truncated folds - beneath the unconformity



Strike Section



Dip Section

- 3. Anticlinal domes



- 4. Fault Traps



- 5. Basal Permian Stratigraphic Traps



Vertical migration up faults and along the unconformity may be significant factors in filling such traps. Jurassic faulting is heterogeneous - some faults do not penetrate below the unconformity, some were sealed at the end of the Jurassic dolerite intrusion, whilst in other cases Tertiary re-activation may render some Jurassic faults 'leaky'. It should be noted that geophysical evidence (Leaman) suggests the permit area has been little affected by Cretaceous and Tertiary faulting (unlike many other parts of Tasmania) and appears to have been relatively stable since the Jurassic. This has significant implications for the integrity of the post-Jurassic seals, which are essential to entrapment of hydrocarbons generated in Cretaceous or Tertiary time. The likely 'leakiness' of some of the faults suggests that gas accumulations would be less effectively trapped because of their greater relative permeability compared with liquid hydrocarbons. However the integrity of the seals is one of the major risks associated with the play in EL 29/84.

COMMENTS

The criteria for a commercial oil-field may be summarized as follows:

1. The accumulation of sufficiently organic rich, oil-prone source material within sediments.
2. Heating of these sediments to a temperature at which oil is generated.
3. Migration of this oil into reservoirs of sufficient size to contain a significant amount of the oil generated.
4. The presence of an adequate seal to prevent further vertical migration of the oil.
5. A trapping mechanism, generally relating to structuring within the rock, (folding, faulting), but also frequently involving lateral changes in rock composition.
6. Preservation from later erosion, fracturing of seal, destruction of the reservoir by excessive heating or chemical changes, etc. In particular it is essential for sufficient reservoir quality to be preserved to enable oil to flow into a well-bore at an adequate rate.
7. A production mechanism which facilitates flow from the reservoir, preferably by utilizing its own energy, e.g. water-drive, gas-expansion drive. - In the absence or depletion of such a mechanism it becomes necessary to install an artificial lift system, usually pumps.
8. Access to infra-structure allowing transport of crude to market at an acceptable price.

Exploration for petroleum is thus restricted to sedimentary basins and requires acquisition of information relating to:

1. Stratigraphy - the distribution, description and classification of the rocks occurring in the basin and their inter-relationship with respect to both time and space. This usually involves firstly field mapping then inspection of any well data; hopefully this identifies potential source and reservoir rocks.
2. Geochemistry - to evaluate the suitability of these potential source rocks with respect to (i) organic content
(ii) oil vs. gas propensity
(iii) thermal maturity.
3. Structure - Regional. Identification of depocentres and regional highs, as well as delineation of major structural trends and style. At this stage regional geophysical methods are applicable, i.e. gravity, aeromagnetics and reconnaissance seismic.
 - Detail. In the absence of adequate surface expression of structure or well control it is necessary to obtain subsurface data by means of a detail reflection seismic programme, which allows mapping of a potential trap.

4. Integration of all this data is now required in order to delineate a drilling prospect which will hopefully have the potential to meet the relevant economic criteria, as well as test the validity of the model developed.

Conga Oil's exploration programme for EL 29/84 to date has been based on sound principles and may be summarized as follows:

1. Stratigraphic relationships are already documented for the Permian section, and adjacent stratigraphic information relating to the Early Palaeozoic section (Ordovician-Silurian) has been 'extrapolated' into the permit area to suggest a possible source (Gordon Group carbonates) and reservoir (Gordon Group carbonates and Eldon Group sandstones), as well as explain the seep.
2. Conodont colouration studies in relation to these potential source rocks apparently indicate a level of maturity (1.5 - 2) which places them in the oil-generation 'window'.
3. A sample from the Johnson well seep when analyzed is quoted as having a similar level of maturity to that suggested by the conodonts, and is also regarded as having been derived from a carbonate source-rock.
4. Regional magnetic data has been analyzed to arrive at optimum parameters for the current round of data acquisition; the gravity and magnetic grids proposed will provide more extensive coverage than has hitherto been possible, and allow the data within EL 29/84 to be seen in context.

Nonetheless there are significant problems still to be overcome before it will be possible to adequately evaluate the area's potential. The chief of these are:

1. The lack of exposure of the postulated source and reservoir rocks in the permit, thus requiring that assumptions be made on the basis of analogy with sections mapped or drilled elsewhere in southern Tasmania. Note however that this is not an unusual problem in Australia - the rocks of the Cooper Basin have no outcrop exposure and were not perceived as a target when drilling first commenced.
2. The presence of extensive dolerite intrusions both within and overlying the Permian section in EL 29/84 has potentially nasty implications for the acquisition of adequate quality seismic data, and the interpretation thereof. Intrusives may also present a problem during drilling.
3. The age of the prospective sediments (Ordovician-Silurian) may present some problems with respect to anticipated reservoir quality, but the experience of the Amadeus Basin producers would suggest that flows of around 900 bpd can be realized from an adequate section of pay, provided careful attention is paid to the drilling programme in order to avoid formation damage.

CONCLUSIONS

1. The location of Bruny Island in such close proximity to Hobart (although this city does not at present have a refinery), and with easy access to shipping facilities, suggests that even a moderate to small size oil-field (500,000 bbl) or alternatively a moderate size gas-field (100 bcf) would be most attractive in a commercial sense. Transportation costs are likely to be minimal compared, e.g., with the Amadeus Basin, where these costs may be as high as \$10 - \$12 per barrel.
2. Progress to date has utilized a combination of basic technique and innovative thinking to arrive at a valid exploration play. Although the occurrence of seeps is not an infallible guide to commercial accumulations of hydrocarbons it is an encouraging factor which suggests that at least the first two criteria of those listed above have been met.
3. The current geophysical programme appears soundly planned and should provide useful information for assessment of the permit. However, I remain sceptical as to its ability to adequately define a target for drilling, except in a very general sense; the precision of the methods employed would not normally be regarded as adequate for the purpose.
4. Acquisition of seismic is of vital importance to the evaluation and possibly ultimate exploitation of the exploration play in EL 29/84. The difficulties arising from the 'masking' effect of dolerite sills and the unconformity, as well as the difficulties presented by the surface weathered layer and sand deposits are likely to be considerable, but not necessarily insuperable.

RECOMMENDATIONS

1. The seeps of Bruny Island and the adjacent mainland (e.g. at Cygnet) should be systematically investigated to more fully evaluate their significance. This will undoubtedly present difficulties with regard to location but could possibly be handled as an honours project for a student. Sampling of the 'scum' at Johnsons Well would also be of value.
2. It is advisable to seek written expert opinion on the significance of the Johnsons Well seep analysis. Verbal opinions are not acceptable in the industry. Dr. McKirdy at AMDEL is one of the recognized authorities in this area, and others are available on a commercial basis if a choice is desired; e.g. W.A.I.T. (W.A. Institute of Technology) also offer this service.
3. Sampling of the nearest Gordon Limestone outcrops for geochemical (source potential) analysis is also required. However, samples of reservoir characteristics from outcrop specimens are liable to have only limited relevance for subsurface conditions.
4. The cost of a full scale seismic programme is likely to prove prohibitive given current budget restrictions, due to the high cost of mobilizing and demobilizing equipment and crews from the mainland. Nonetheless it is imperative that every effort is made to conduct at least an experimental programme utilizing, if possible, Tasmanian Mines Department equipment, for the purpose of establishing optimal field acquisition parameters and analyzing the

nature of the problems presented by the presence of the dolerite. More complete analysis will require subsurface well data. Although the magnetic and gravity data which should be available later this year will be of considerable assistance in evaluating the potential of the permit and delineating broad areas of interest, it is most likely that true prospect definition will still require seismic coverage.

5. If the AMOCO records for their offshore Storm Bay Survey can be obtained in field tape form it would seem to be worth attempting some experimental re-processing to see if it is possible to obtain deeper data than is presented in their processed sections. The age of this shooting (1971) however would probably limit the potential for any significant breakthrough.
6. Given the uncertainties regarding stratigraphy and structural style, and the difficulties and costs associated with seismic, I feel the company should seriously consider the drilling of a stratigraphic well after the latest geophysical data has been interpreted and is available to assist in selection of an appropriate site. Such a well would be expected to provide information essential to progressing the exploration of this permit, in particular:
 - (a) The nature and size of the dolerite intrusions in the Permo-Triassic section.
 - (b) Stratigraphic relationships - in particular the vital question of just what is the lithologic nature of the pre-Permian sequence will be answered.
 - (c) The source potential of all sediments penetrated can be assessed.
 - (d) Core and log data will supply valuable information regarding the reservoir quality of the potential targets.
 - (e) Velocity and density data essential for calibration and interpretation of seismic will be obtained.
 - (f) Hydrocarbon shows can be continuously monitored to help identify potential reservoirs.
 - (g) Dipmeter well-logs and core information can assist in interpretation of the structural picture and conditions of deposition.

The unconformity is expected to lie at around 1000 metre, and it would be advisable to programme such a well to drill at least 1000 metre of section below the unconformity to allow for an Eldon Group section being encountered before reaching the Gordon Limestone. Since this will be the first well to drill this section it will be important to select a well-log and coring programme capable of extracting as much information as possible from the well.

The work undertaken to date has established a valid but difficult exploration play. The programme is still at an early stage, and progress is not going to be either easy or rapid unless some of the key problems outlined above are solved early on: in particular unless it proves possible to obtain usable seismic then adequate definition of prospects will present an almost impossible task.

However the economic factors for this area (cost of transport in particular) are most attractive, and would appear to warrant a sustained exploration effort aimed at evaluating the hydrocarbon prospects of this

BIBLIOGRAPHY

- Burrett, C., Stait, B., Sharples, C. and Laurie, J., "Middle-Upper Ordovician Shallow Platform to Deep Basin Transect, Southern Tasmania, Australia." Reprint from Bruton, D.L. (Ed.), 'Aspects of the Ordovician System,' Universitetsforlaget, 1984.
- Burrett, C., Stait, B., Laurie, J., University of Tasmania, "Gordon Subgroup (Ordovician) Carbonates at Precipitous Bluff and Point Cecil, Southern Tasmania, Australia." Papers and Proceedings of the Royal Society of Tasmania, Vol. 115, 1981.
- Burrett, C., Geology Department, University of Tasmania, "Petroleum Prospectivity of Central Southern Tasmania - a Preliminary Report," for Conga Oil, 1986?
- Clarke, M.J. and Banks, M.R., "That Stratigraphy of the Lower (Permo-Carboniferous) Parts of the Parmeener Supergroup, Tasmania."
- Corbett, K.D. and Banks, M.R., University of Tasmania, "Ordovician Stratigraphy of the Florentine Synclinorium, Southwest Tasmania." Papers and Proceedings of the Royal Society of Tasmania, Vol. 107, 197..?
- Hughes, T.D., "Limestones in Tasmania," Bulletin 10, Geological Survey Mineral Resources, 1957.
- Leaman, D.E. and Naqvi, I.H., "Geology and Geophysics of the Cygnet District," Geological Survey of Tasmania, Bulletin No. 49, 1967.
- Leaman, D.E., "Gravity Survey of the Hobart District," Geological Survey of Tasmania, Bulletin No. 52, 1972.
- Leaman, D.E., "Form, Mechanism and Control of Dolerite Intrusion near Hobart, Tasmania," 1975.
- Leaman, D.E., "Geological Survey of Tasmania Explanatory Report, Hobart Sheet, 1:50,000 Series", 1976
- Leaman, D.E., "Review of pre-1987 Geophysical and Structural Data D'Entrecasteaux Channel Region Tasmania," for Conga Oil, February, 1987.
- Spry, A., and Banks, M.R. (editors), "The Geology of Tasmania," Journal of the Geological Society of Australia, Vol. 9, Part 2, 1962.
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Appendix 5

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LEAMAN GEOPHYSICS

Survey Review, Specification, Reduction, Interpretation
Wide Experience Most Methods
Specialties: Gravity, Magnetics, Seismic Methods

Registered Office:
461 OCEANA DRIVE, HOWRAH, TAS. 7018
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1987 GRAVITY SURVEY
PROJECT D'ENTRECASTEAUX

CONGA OIL PTY LTD

Following a preliminary assessment of available gravity data in southeast Tasmania which established the value of the gravity method as an aid to resolution of both dolerite and pre-Permian structuring additional data was acquired. This was essential outside the Cygnet and Catamaran areas since the existing TASGRAV data base was limited south and west of Margate.

The aim of the survey was provision of a greatly improved coverage and definition of the gravity field across the study area with some infill between the Huon River and the D'Entrecasteaux Channel and on Bruny Island where the primary coverage was poor to fair. The initial budget set aside for the survey meant that only those sites readily accessed could be observed and no attempt was made to generate a regular or uniform station distribution. It was felt that if such further improvement was needed that the new survey and its interpretation would reveal those zones in which more data acquisition would be critical or advisable.

Consequently all available road access and some of the better vehicular tracks were utilised. Where any track presented problems (as by washout, fallen trees, locked gates and hard to find owners, etc) the traverse was terminated. No walking of stations was entertained.

Application of these principles has produced a considerably improved data base but there are still major gaps both within the developed areas and in the less accessible regions marginal to them. A second generation survey using helicopters and walking tracks could resolve any deficiencies. It is not yet known if this will be necessary.

Specification and supervision:

The survey was supervised and specified by Dr. D. Leaman of Leaman Geophysics, Hobart.

A tie station network was formed which was ultimately tied to BMR Isogal station 6091.0260 at Mount Nelson and cross linked to 6851.9354 at Snug.

A nominal station spacing of 1 to 2km was to be employed on all traverses.

Elevations were barometrically determined using base barometers, multiple roving barometers and spot control methods coupled with many repeat observations.

Contractor:

Solo Geophysics of Adelaide, Graham Rao observer.

Period of survey:

March 13 to April 24, 1987

Active licences during survey:
Only EL 29/84. Others pending and not advised.

Reductions:
Completed, checked and integrated with Tasgrav data by May 1, 1987 using a density of 2.67 t/cu m. Reductions by Leaman Geophysics.

Costs:
Survey: \$24874
Reduction: 5180

\$30054 or \$35.36 per station

Tie station detail:

Base reference Mt Nelson:	6091.0260	980389.56
Snug	: 6851.9354	980467.47
Huonville bridge NE	: .9902	980459.03
Port Huon wharf	: .9903	980475.94
Geeveston 4 ft bridge	: .9904	980465.58
Dover library	: .9905	980487.59
Strathblane hall	: .9906	980490.82
Southport/Hastings jn	: .9907	980492.42

Survey and compilation notes:

Some mismatches were noted between Tasgrav values and the new survey. These related mostly to old barometric surveys which lacked the benefit of new techniques and the good control now provided by Lands maps. Most previous work predates 1970 when basemaps were generally unavailable.

Other problem stations have been identified by reviewing patterns within the gravity field or the consistency of results upon re-occupation of sites. In most cases the Bouguer anomaly is within 0.5 mGal which indicates a long history of sound technique and reliable base networks.

Where possible, errors have been traced and the stations corrected. Very few have been deleted. In the case of parts of the Cygnet (6560), Hobart (6851) and Marathon (8050) surveys most errors relate to elevation but occasionally gravity difference or terrain correction errors were noted. Where height errors were recognised the precision on recovery is probably no better than 2 to 4 m. It must also be appreciated that no more than 30 stations were affected by any of these problems and only three were deleted from the data base.

The final recovery and compilation as presented at May 1, 1987 is satisfactory for the regional objectives of the D'Entrecasteaux project but any detailed replot of survey 6560 west of Cygnet should be reviewed with moderate caution and survey 8050 west of Lune River requires some additional confirmatory coverage. There may still be odd stations in these surveys which are suspect in elevation. The compilation provided uses a subset of the Marathon (8050) data and is thus

partly filtered to provide a nominal 500 to 1000 m spacing. Very detailed coverage of local areas within the Hobart district have been similarly treated.

Several BMR traverses in Storm Bay have also been compiled. All stations listed on the BMR marine file have been reduced. Not all were assigned water depths on that file and estimates have been inserted using the supplied coordinates and Admiralty charts. These depths are likely to be accurate to within 5 m in most cases although some sites may be suspect by up to 10 m. These problems are, however, minor compared to the variation in results generated by the various surveys and traverses, and along some traverses. I suspect that not all corrections have been properly applied on ship and the plot is based only on those values which afford some consistency, both internal and between surveys. The entire Storm Bay result should be considered suspect until confirmed by new survey.

Precision:

Observed gravity: Stations reproducible to within 0.03 - 0.05 mGal after loop and drift correction.

Elevation: Generally better than 2 m; equivalent to an error of about 0.5 mGal in the Bouguer anomaly.

Position: Generally better than 100 m; equivalent to an error of no more than 0.1 mGal in the Bouguer anomaly.

Terrain correction: variable but estimated at 5% based on reproducibility; or about 0.05 to 0.15 mGal for most stations.

The RMS error is of the order of 0.6 mGal. Many stations will be much better than this but some could be of the order of 1 mGal. A general 2 mGal contour interval is justified. Some areas could be contoured at 1 mGal contour interval.

D. E. Leaman
May 1, 1987

8700.0719	532850.0	5219800.0	114.0	980467.10	980464.60	1.00	25.82
8700.0720	532900.0	5218850.0	119.0	980468.80	980465.40	1.10	27.88
8700.0721	533150.0	5218600.0	130.0	980466.70	980465.60	1.72	28.35
8700.0723	527350.0	5219350.0	1.0	980487.80	980465.10	0.18	23.11
8700.0725	526100.0	5219600.0	1.0	980485.40	980464.80	0.84	21.55
8700.0726	525350.0	5219200.0	1.0	980486.80	980465.20	0.76	22.52
8700.0730	526800.0	5218700.0	1.0	980489.60	980465.60	0.10	24.32
8700.0731	528000.0	5218350.0	1.0	980490.60	980465.90	0.35	25.27
8700.0732	528900.0	5218400.0	1.0	980490.50	980465.80	0.24	25.13
8700.0733	529250.0	5219000.0	1.0	980489.80	980465.30	0.21	24.83
8700.0740	532250.0	5219250.0	33.0	980486.80	980465.10	0.20	28.40
8700.0741	532200.0	5218900.0	73.0	980477.40	980465.40	0.37	26.76
8700.0742	531800.0	5218700.0	30.0	980486.10	980465.60	0.19	26.67
8700.0743	531550.0	5219150.0	12.0	980487.90	980465.20	0.20	25.27
8700.0744	532900.0	5217950.0	132.0	980466.40	980466.10	1.30	27.48
8700.0745	532250.0	5217900.0	40.0	980486.20	980466.20	0.25	28.19
8700.0746	531900.0	5218250.0	20.0	980489.30	980465.90	0.15	27.46
8700.0747	532850.0	5217600.0	111.0	980472.10	980466.40	1.08	28.52
8700.0748	533050.0	5214750.0	160.0	980464.40	980468.80	1.10	28.19
8700.0749	533000.0	5214150.0	178.0	980462.60	980469.20	1.70	30.11
8700.0750	532950.0	5213150.0	177.0	980464.20	980470.10	1.60	30.61
8700.0751	532750.0	5212350.0	96.0	980481.60	980470.70	1.00	30.77
8700.0752	532450.0	5211950.0	1.5	980501.50	980471.00	0.44	31.22
8700.0753	531200.0	5211450.0	10.0	980498.20	980471.40	0.15	28.84
8700.0754	531800.0	5212200.0	2.0	980500.40	980470.80	0.25	30.18
8700.0755	531025.0	5212600.0	3.0	980498.50	980470.50	0.16	28.75
8700.0756	530700.0	5213400.0	8.0	980497.10	980469.90	0.16	29.01
8700.0757	530125.0	5213900.0	15.0	980494.10	980469.40	0.23	27.76
8700.0758	530150.0	5214600.0	5.0	980495.80	980468.90	0.20	28.06
8700.0759	531400.0	5214350.0	121.0	980475.80	980469.10	2.00	32.50
8700.0760	531100.0	5214850.0	85.0	980482.50	980468.70	0.69	31.21
8700.0761	531450.0	5215050.0	61.0	980486.40	980468.50	0.32	30.25
8700.0837	530500.0	5215350.0	1.0	980496.80	980468.20	0.38	29.06
8700.0838	529550.0	5215750.0	1.0	980494.90	980467.90	0.29	27.45
8700.0839	528300.0	5215350.0	1.0	980494.60	980468.20	0.10	26.59
8700.0840	527600.0	5214600.0	1.0	980494.90	980468.90	0.12	26.29
8700.0841	528250.0	5212050.0	1.0	980499.10	980470.90	0.15	28.52
8700.0842	528200.0	5212600.0	1.0	980498.30	980470.50	0.15	28.17
8700.0843	528800.0	5213000.0	1.0	980497.50	980470.20	0.10	27.62
8700.0844	528350.0	5213600.0	1.0	980497.60	980469.70	0.16	28.23
8700.0845	534100.0	5212550.0	33.0	980495.60	980470.50	0.38	31.97
8700.0846	533700.0	5213100.0	18.0	980497.40	980470.10	0.31	31.21
8700.0847	533850.0	5213650.0	25.0	980496.20	980469.60	0.27	31.72
8700.0848	533900.0	5214150.0	41.0	980492.40	980469.20	0.26	31.52
8700.0849	533750.0	5214700.0	49.0	980490.70	980468.80	0.30	31.81

GRAVITY STATIONS ACQUIRED WITHIN EL 29/84 : 1987 SURVEY

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CONTRACT

D'ENTRECASTEAUX MAGNETIC SURVEY
SOUTHERN TASMANIA

FOR
CONGA OIL PTY LTD.

BY
AUSTIREX INTERNATIONAL LTD.

CONTRACT

SCHEDULE ONE1. PROJECT

The name of the project is "D'Entrecasteaux magnetic survey Southern Tasmania."

2. WORK TO BE PERFORMED

The work to be performed by the Contractor consists of the acquisition, processing and presentation of airborne magnetic data in one survey block in Southern Tasmania.

The work to be performed consists of:-

- a) a survey block within the AMG co-ordinates 470 000mE to 555 000mE and 5170 000mN to 5250 000mN.
- b) a survey with flight lines flown with an orientation of 090 degrees and 270 degrees magnetic. The flight line spacing shall be 2.5 kilometres and the sensor height will be 1000m above sea level.
- c) tie lines flown generally perpendicular to the flight lines at a line spacing of 10 kilometres and the sensor height will be 1000m above sea level.
- d) an approximate total of 3,280 linear kilometres including traverse lines and tie lines.

3. CONTRACTOR'S OBLIGATIONS3.1 Survey navigation, flight path recovery and synchronisation

- a) The Contractor will use electronic radio positioning equipment for navigation and flight path recovery.

The system to be used will be the Syledis long range UHF radionavigational system. Syledis is an over the horizon radio ranging technique which provides high accuracy position determines for a mobile station from two or more fixed beacons in real time. The Syledis position information will be directed for navigation of pre-determined flight lines and subsequently recorded on digital tape along with the geophysical data.

b) Fill-in flight lines:

Fill in flight lines will be required at the expense of the Contractor if flight line plots show gaps between individual flight lines in excess of 50% of line spacing over a distance of more than 10% of the line length.

Reflighting of fill-in lines or repeated flight lines will be required at the expense of the Contractor if flight path recovery or geophysical data do not comply with these specifications. Fill in lines or repeat lines must be of sufficient length to cross at least two tie lines.

c) Synchronisation:

The geophysical data and navigation systems will be synchronised to a 1.0s time base generator. The magnetometer will be sampled twice each cycle, giving an effective sampling rate for the magnetometer of 0.50s. The average sample distance along each flight and tie line for the magnetometer will be about 30m.

3.2 Data to be provided by Contractor:

a) Original data required at conclusion of processing:

All data will be correctly annotated before being delivered to the Principal. Analogue charts will be edited, folded and bound. The following is a list of data which will be delivered.

Magnetic charts and digital records;
Barometric-altimeter charts;
Magnetometer storm warning charts and diurnal records;
Flight logs - originals;
Flight index - originals;

b) Processed data to be provided by the Contractor:

The Contractor shall reconstruct flight path plots and provide contour plans and profiles of magnetic intensity after removal of the IGRF.

i) Flight Path Maps:

The flight path maps will be prepared to high-order cartographic standards and plotted on stable base film. Final maps will be prepared at a scale of 1:100,000. The maps will be produced using a transverse Mercator projection and a format as specified by the Principal.

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ii) Magnetic Contour Maps:

The magnetic data will be levelled from diurnal and tie line records, the effect of the IGRF will be removed and contours of residual field plotted at a selected intervals. Final maps will be prepared at a scale of 1:100,000. The map formats will be prepared as in (i) above.

iii) Stacked magnetic profiles.

The Contractor will prepare stacked profiles of the reduced magnetic data. Final maps will be prepared at a horizontal scale of 1:100,000. The vertical scale shall be chosen by the Principal.

iv) Colour coded magnetic contours.

The Contractor will prepare a contour map of residual magnetic intensity using different coloured contour lines. The contour interval chosen for each of the colours will be decided by agreement between the Contractor and the Principal.

v) Werner deconvolution profiles.

The Contractor will provide Werner plots of all or selected lines. Each plot will show total field magnetics, depth, horizontal location, dip and susceptibility parameters for both thin dyke and edge solutions. Presentation scale will be 1:100,000.

vi) Located data tapes.

The Contractor will prepare located data tapes of the reduced geophysical data.

vi) Logistics report.

The Contractor will provide a logistics report at the conclusion of the survey. This logistics report will include:

- a) Survey specifications;
- b) Description of survey equipment and data acquisition equipment including base station magnetometer;
- c) Description of procedure used to conduct system calibration and checks;
- d) Results of all pre and post flight system calibration checks, and all test flight lines; and
- e) Log of survey logistics and navigators logs.

4. PERSONNEL, PLANT AND EQUIPMENT

The Contractor shall provide, maintain and operate at its own expense all aircraft plant and equipment necessary to perform the work.

The Contractor will ensure that qualified personnel are in charge of all aspects of the work.

a) Type of Aircraft:

The Contractor will use a Rockwell Shrike AC500S Aerocommander aircraft, a twin engined aircraft.

The aircraft is fitted with a Collins ALT-50 radio altimeter, and a Penny and Giles barometric pressure sensor. Radar altitude and barometric pressure are digitally recorded.

The aircraft is also fitted with a Sperry-Decca type 72 doppler navigation system coupled with a Tactical Air Navigation system (TANS) computer 9447D. This computer can be programmed to a variety of specific survey functions. Navigation may be in latitude/longitude, metric grid, or range and bearing modes. Navigation information is digitally recorded on magnetic tape with the geophysical data, and is used in conjunction with photographic records to define the aircraft's flight track. The aircraft is also equipped with a Global GNS VLF/Omega navigation system.

b) Electronic Navigation Equipment:

The Contractor will use Syledis positioning equipment comprising one mobile unit, three beacons, navigation computer and support for field stations.

c) Equipment for collection of data:

i) Airborne Magnetometer:

The Contractor will use a Scintrex V2321 alkali vapour magnetometer sensor coupled to a Sonotek AADC automatic digital compensator as the airborne magnetometer. The resolution of the system is 0.01nt at 0.5 seconds sampling and the noise envelope should not exceed 0.10nt's except in extremely turbulent conditions.

The compensated magnetometer data will be recorded both on analogue strip charts, and on digital magnetic tape. The analogue charts will show the coarse and fine magnetometer record. The full scale deflections on these charts will be adjusted according to magnetic activity expected in the survey area, but are typically 0-100 nT and 0-1000 nT.

ii) Ground Magnetometer:

The Contractor shall use a modified Geometrics G856 proton magnetometer, coupled to a HP 85 computer as the base station magnetometer. The recording sensitivity of this magnetometer is 0.01nT. This magnetometer will be cycled each 20 seconds.

iii) Altitude Measurements:

The Contractor will measure and record digitally the ground clearance and barometric pressure at each data point. A Collins ALT-50 radio altimeter and a Penny and Giles barometric pressure sensor will be used. The barometric altimeter record will be recorded on analogue charts in real time.

iv) Ground Tracking Camera:

The Contractor will use a Geocam model 75SF 35mm single frame camera, fitted with a 17mm wide angle lens, to monitor the aircraft flight path. The focal length of this camera ensures ground coverage overlap on exposed film. The fiducials are imposed on the exposures.

v) Analogue Chart Recorders:

The Contractor will use a Watanabe multi channel recorder for magnetic, altimeter and fiducial data recording. Combinations of some selected channels can be multiplexed.

vi) Computer Equipment:

The Contractor will use the following computer equipment for data compilation and map preparation:

- one Data General MV/10000 supermini computer with 6 Mb real memory;
- 1.2 GB on-line storage
- eight 9 track 800 bpi magnetic tape units and two 1600 bpi units;
- one Calcomp 9100 digitiser;
- one Calcomp 960 high speed plotter;
- one 300 lpm line printer;
- eight VDU's and two graphic terminals.

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d) Geophysical Operations:

Strict quality control of data shall be maintained with equipment calibration being checked before and after each flight. If during the course of a flight it is necessary for the flight to be aborted due to insufficient daylight or equipment failure, then the aborted flight line will be repeated in whole, or between appropriate tie lines, at the Contractor's expense.

e) Magnetic diurnal activity:

On days when magnetic variations greater than 5nT occur in less than 5 minutes, flying, if not already commenced, shall be cancelled. If flying is commenced and if variations greater than 10 nT in 5 minutes are encountered, lines flown during the period of magnetic disturbance must be reflowed. Any tie lines flown during a period in which the variation is in excess of 5nT in 5 minutes shall be reflowed.

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Appendix 6

APPENDIX SIX

PRELIMINARY RESULTS: ANALYSES OF POTENTIAL SOURCE ROCKS

The following preliminary results were received as this annual report was being prepared. They are not complete and several other samples have been submitted for analysis. Complete final results will be tabulated in the next annual report.

Samples were collected by Dr. C. Burrett and Mr. M. Bendall during the period March to June 1987 and sent for analysis by the South Australian Department of Mines and Energy.

		vitrite reflectance equivalent, obs	corr	TOC
ORDOVICIAN				
1B7	Ida Bay, limestone	0.81	0.70	-
1B112	Ida Bay (quarry road), limestone	1.14	1.08	-
A49	Surprise Bay, graptolitic calc shale	1.17	1.12	0.23
SS16	Florentine Valley, Sunshine Spur Road, limestone	0.95	0.88	-
CAMBRIAN				
C1	Chicken Island, limestone	0.83	0.72	-

Notes: All results lie within the oil window. The low TOC is typical of weathered surface samples given that limestones possess low values in any event.