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TASMANIA DEVELOPMENT AND RESOURCES

The Basement Elements Of Tasmania

By:

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The Basement Elements Of Tasmania

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ABSTRACT

A new compilation of magnetic data over onshore and offshore Tasmania plus existing geological mapping and gravity data has provided the basis for the production of a map illustrating the geometric distribution of the main basement units that comprise Tasmania. Significant items of the new interpretation map include the delineation of the widespread sub-surface granite occurrences in Tasmania, identification of more extensive occurrences of Proterozoic rocks than previously known, mapping of the extent of the Dundas Trough and extensive northwestern and southeastern continuations of the Beaconsfield ultramafics, definition of the areal distribution of Mesozoic sedimentary basins and the control of Proterozoic lineaments, in particular the Arthur Lineament, on the development of the Mesozoic basins. The use of filtering techniques to suppress the magnetic effects of shallow magnetic sources proved particularly valuable for mapping deeper structures obscured by basalt flows and dolerite dykes and sills.

INTRODUCTION

A new aeromagnetic map of Tasmania (Figure 1), jointly released at 1:500 000 scale in November 1995 by the Australian Geological Survey Organisation (AGSO) and Tasmania Development and Resources (TDR), incorporates existing company and government aeromagnetic data over onshore Tasmania plus 90 100 line kilometres of additional data, acquired over offshore areas by AGSO during 1994. This map provides the basis for an interpretation of the distribution and structural relationships of the basement lithological units that comprise Tasmania. A simplified map of the known outcrop geology of Tasmania is shown in Figure 2. The objective of the interpretation was to clarify the relationships of the known geological units and the tectonic framework of Tasmania in a manner that will assist exploration for resources. The output of the exercise was a 1:1 000 000 map of "Major Basement Elements of Tasmania" (Figure 3). The interpretation has focused on defining the geometrical distributions of the various units and has left speculations on the nature and evolution of the various units to later workers.

The interpretation was completed in one week. This was achieved by pre-loading images of the aeromagnetic data plus other relevant data sets into a work-station as Arc/Info GIS layers and then assembling a team of eight specialist geoscientists at the location of the workstation, where, in a process of active consultation, using hardcopy and on-screen image overlays, a mutually agreed interpretation was achieved. The collaborators who produced the interpretation comprised an efficient mix of processing and GIS specialists, aeromagnetic interpreters and geologists with considerable local knowledge relevant to most of Tasmania. Real time on-screen tracing and editing of the interpretation allowed a colour, publication standard, hard copy interpretation to be produced at the end of the five day interpretation period.

AVAILABLE DATA

The data sets used for the interpretation were:

(i) *Digital geographic information in vector format.* The coastline used was the Australian Survey and Land Information Group (AUSLIG) 1: 100 000 scale coastline of Tasmania.

(ii) *Digital elevation model of Tasmania.* This data, prepared as part of a joint project by AGSO and AUSLIG to establish a digital elevation model (DEM) of Australia, consisted of elevation values on a 200 metre grid. A colour scaled gradient enhanced image was the basic overlay used during the project (Figure 4a).

(iii) *Outcrop geology in vector format.* This was based on compilation and generalisation of detailed mapping for production at 1:250 000 scale by Mineral Resources Tasmania. Hard copy geological maps were available for reference.

(iv) *Bouguer gravity values.* Grids and contours of the Bouguer gravity values were available incorporating various processings of these data by Roach et al. (1993). The most useful product for interpretation purposes was a residual field from which field distortions caused by the boundary between continental crust and oceanic crust on the east and west coasts of Tasmania and the Moho topography had been removed [Figure 4b corresponding to Figure 6b of Roach et al. (1993)].

(v) *Total magnetic intensity.* A new composite total magnetic intensity grid (cell size 100 metres) incorporating the results of various surveys over Tasmania and adjacent offshore waters between 1981 and 1994, published by Mackey et al. (1995), provided the basis for the interpretation. These data were available as various hard copy images and contour presentations. To optimally view the information content of the aeromagnetic grid it was necessary to apply various mathematical and visual enhancement processes. These are described in the following section.

SPECIALISED ENHANCEMENTS OF THE AEROMAGNETIC DATA

A comprehensive description of the various transformations and enhancements applicable to aeromagnetic data is given by Milligan and Gunn (1996). The following selection, used for the interpretation project, was produced using the INTREPID processing system in conjunction with the ER Mapper image processing software.

Versions of total magnetic intensity and contours

The published versions of the total magnetic intensity field of Tasmania were a colour histogram equalised gradient enhanced image (Figure 1) and a greyscale histogram-equalised east-west gradient enhanced image (Figure 5a). These images give excellent overviews of the general characteristics of the magnetic field with the colour image having the advantage that it clearly displays relative intensities. The greyscale representation gives superior detail for subtle linear features. The east-west illumination direction was chosen as this is an optimal enhancement direction to emphasise features related to the predominant northerly structural trends that occur in Tasmania. It must be appreciated that features with east-west trends are not optimally imaged with such an enhancement.

Enhancements using sun angles produce shadows on the sides of anomalies facing away from the "sun". Often such shadows can confuse the overall perception of anomaly shapes and amplitudes and for this reason a non-enhanced image using the Comtal colour palette was produced to give a straightforward representation of the constituent anomalies of the magnetic field over Tasmania (Figure 5b).

A simple hard copy contour map of the magnetic intensity values was used to check detail on anomaly forms, contour gradients and anomaly amplitudes. Anomaly gradients, which are indispensable for qualitative depth and dip estimates, cannot always be determined from images.

Vertical gradient

A vertical gradient of the total magnetic intensity was computed and displayed as a colour histogram-equalised gradient-enhanced image (Figure 5c) and a greyscale histogram-equalised east-west gradient-enhanced image. The vertical gradient process enhances short wavelength (shallow source) anomalies and suppresses long wavelength (deep source) anomalies. In the case of the Tasmanian data, the process improved resolution of anomalies buried within or below sedimentary basins, but for situations involving near-surface magnetic sources the results in many cases tended to resemble semi-random assemblages of noise. This was due to aliasing in poor quality, wide line spacing data in various portions of the dataset. This was particularly evident in areas covered by Jurassic dolerites. The onshore vertical gradient results did not generally provide more useful information than the gradient enhanced total magnetic intensity images at the scale of the interpretation exercise.

Upward continued magnetic intensity

In contrast to the vertical gradient transformation, the upward continuation process results in a smoothed field as the method supresses the effects of short wavelength anomalies relative to long wavelength anomalies. For the Tasmanian data the total intensity field was recomputed at a level 1000 metres above that of the original surveys (Figure 5d). The result shows a significant diminution of the magnetic effects of the magnetic anomalies due to isolated and shallow sources, relative to the magnetic effects of deeper and more regional sources.

Low pass filtered magnetic intensity

An effect similar to upward continuation can be produced by applying a high-cut filter to remove short wavelengths from a magnetic dataset. It should be appreciated that the results, while being applicable to the visual interpretation of magnetic datasets, have a mathematical meaning rather than a true physical meaning as is the situation with upward continued fields. Figure 5e shows the total magnetic intensity field for Tasmania after all wavelengths less than 5000 metres have been removed. The image of Figure 5e shows an even clearer delineation of regional magnetic anomalies than the upward continued image of Figure 5d.

Matched filtered magnetic intensity

It is possible by studying the distribution of frequencies comprising a magnetic field, to relate frequency distributions to magnetic markers at various depths. The actual form of the frequency distribution can be used to specify filters to separate the frequencies corresponding to these various markers. The process has been described by Spector and Parker (1979) who call the process matched filtering. Figure 5f shows the results of a matched filtering process that has been designed to eliminate all magnetic effects from the Tasmanian data except those arising from deep and/or major magnetic units. This process has resulted in a severe and dramatic culling of all anomalies due to minor and/or shallow sources. The results show the magnetic responses of the major magnetic blocks that comprise the basement in Tasmania.

No processing to reduce the magnetic field to the pole has been applied. The justification for this omission is that the magnetic latitude of the centre of Tasmania is 72 degrees and consequently distortions of magnetic anomalies due to induction effects are minimal i.e. the forms of magnetic anomalies in the various magnetic maps and images produced will, in the absence of significant remanent magnetisation, give accurate representations of the positions and forms of their sources. A test of a reduction to the pole transformation on the dataset showed that this is in fact the case.

INTERPRETATION RESULTS AND THEIR SIGNIFICANCE

The features described in the following account are illustrated in Figure 3. Elaborations on the known geology that applies to the various features can be found in Burrett and Martin (1989), Seymour and Calver (1995), and the specific additional references quoted.

Devonian Granitoids

Many of the granites of Tasmania are non-magnetic (Collins et al., 1981, table 1). The outline of these bodies can sometimes be determined by relatively quiet magnetic zones within areas of magnetic lithology, but the clearest definition of their extent is normally given by gravity lows (Leaman and Richardson, 1989).

A number of major granite batholiths, apparently a continuation of the Wilson's Promontory (Victoria) and Flinders Island trend, are evident as a major gravity low along the east coast of Tasmania (G1). The gravity low correlates with outcrops of Devonian granitoids in northeastern and eastern Tasmania. The continuation of the gravity low over areas underlain by Ordovician-Early Devonian Mathinna Group rocks, Permo-Triassic Parmeener Super-group rocks and Jurassic dolerites, shows it to be much more extensive at depth than is indicated by granitoid outcrops.

Other major granite intrusions indicated by gravity lows underlie the Tyennan Region at locations indicated by G2 and G3. The extents of various other onshore granites can be inferred by combinations of outcrop geology, quiet magnetic zones and gravity lows (Leaman and Richardson, 1992).

An extensive magnetic low around granite outcrops on Three Hummock Island clearly suggests a subcircular granite (G4). The magnetic high surrounding this feature is characteristic of a magnetic aureole.

Magnetic lows G5, G6, and G7 suggest other offshore granites although these features could simply be due to areas of non-magnetic rock.

The large Housetop granite (G8) is moderately magnetic (Collins et al., 1981, p.59-60) unlike most other Devonian granitoids in Tasmania. Some small granodiorite bodies in eastern Tasmania are also moderately magnetic (Collins et al., 1981).

Ultramafics of Northeast Tasmania

The Beaconsfield Ultramafic is an extensive linear slice of ultramafic rock emplaced along a complex fault zone west of the Tamar River. This linear feature is referred to, in part, as the Tiers Fault (Leaman, 1994). These rocks are strongly magnetic (U1) and the magnetic data clearly suggests the existence of several other slices of ultramafic rock along a zone which is parallel to the Tamar River, and which appears to be truncated by the Devonian granitoids at its southern end and by the Arthur Lineament (discussed below) at its northern end (Figure 3).

A series of major magnetic anomalies, parallel to the ultramafics of the Beaconsfield trend and east of them, have been interpreted by Roach (1994) as being possibly due to thrusted slices of ultramafic rocks (U2).

Proterozoic of Western Tasmania

The major features in the magnetic data corresponding to the Proterozoic rocks of western Tasmania are:

(i) *A major north-trending zone of highly magnetic rocks offshore from the west coast (P1).*

The only control on identifying this lithological element are outcrops of volcanics of inferred Neoproterozoic age that correlate with the edge of the zone on the east coast of King Island and the results of the Clam 1 well (Esso, 1969) which bottomed in phyllites of Proterozoic age (Moore et al., 1992). These facts together with the location of this unit between known outcrops of Proterozoic rocks on King Island and mainland Tasmania suggest it is possibly also of Proterozoic age. The aeromagnetic map of Australia (Tarlowski et al., 1996) shows that this unit continues, without dislocation, under Bass Strait virtually to the Victorian coast in the vicinity of the Mornington Peninsula. Initial results from a recent research cruise by Mineral Resources Tasmania to numerous small islands between Tasmania and King Island recovered no samples to account for the deep-sourced magnetic anomalies observed in this area. The southern portion of the zone along the west coast of Tasmania appears to have been dislocated by the Mesozoic separation of the Australian and Antarctic continents.

(ii) *Other Units in the Proterozoic*

The magnetic map shows many elongate linear features within the Proterozoic which appear to represent magnetic responses of metasediments and or mafic volcanics. These give an excellent indication of the structural grain, however only major features of this type have been indicated in Figure 3 in order to clarify their representation. What are especially apparent, however, are basaltic volcanics in the Neoproterozoic Smithton Synclinorium (P2).

(iii) *The Arthur Lineament*

An extended composite zone of highly magnetic linear units corresponds with the zone of high grade metamorphics known as the Arthur Lineament (P3). The magnetic data show this lineament to extend offshore beneath the Bass Basin, and to possibly also have an extension, disrupted by granite intrusion and offset by Mesozoic basin extension, to offshore areas to the southwest.

The Dundas Trough

The principal components of the Dundas Trough are: Middle to late Cambrian volcano sedimentary and sedimentary sequences which in the macro sense are non-magnetic; ultramafic complexes which correspond to intense magnetic anomalies and which, on a regional scale, are easily mapped with the magnetic data (D1); and the Mount Read Volcanics, a belt of calc-alkaline igneous rocks, with a diverse magnetic signature (D2). The various low-pass filtered images (Figures 5d, e and f) indicate that the Dundas Trough is largely floored by magnetic material. This magnetic material could be continuations at depth of the outcropping ultramafic rocks.

Adamsfield Trough and Equivalents

The Adamsfield Trough contains similar lithological units to the Dundas Trough. Magnetic highs corresponding to outcrops of ultramafic rocks in the Adamsfield Trough area (A1) have similar character to a discontinuous zone of magnetic anomalies extending southward to the New River area (A2), where a magnetic anomaly corresponds to a mapped outcrop of ultramafic rocks. The magnetic data thus suggest an extensive zone of ultramafic rocks corresponding to continuations and/or equivalents of the ultramafics associated with the Adamsfield Trough.

Tyennan Complex

The Tyennan Region of central Tasmania (TY) is primarily comprised of non-magnetic Proterozoic rocks and apart from some broad differences in magnetic character and some localised magnetic anomalies of limited strike length, the regional magnetic data reveal little about the nature of this area.

Bass Basin

The Bass Basin (B) is an extensional feature developed as a result of the separation of the Australian and Antarctic plates during the Mesozoic (Williamson et al.; 1985). The salient features of the aeromagnetic data that can be related to the development of this basin are:

(i) abrupt terminations of the Proterozoic geology, due to faulting associated with extension in a northeasterly direction,

(ii) the offshore continuation of the Arthur Lineament, which appears to have acted as a pre-existing line of weakness that accommodated basin extension in the northeasterly direction,

(iii) a major magnetic intrusion (BP) that underlies the main basin depocentre. This intrusion can be explained as resulting from magma generation due to mantle depressurisation associated with basin extension and crustal thinning beneath the basin.

The above interpretations are explained in detail by Gunn et al. (1996a).

Durroon Basin (D)

The Durroon Basin (Baillie and Pickering, 1991) is a predominantly Cretaceous feature east of the Bass Basin which is structurally distinct from the Bass Basin. The basin, manifesting itself at depth as a series of northwest-trending half grabens, does not appear to have undergone the same degree of extension as the Bass Basin. The magnetic data appear to be mapping a series of basalt flows that have been confined to the half grabens. Offsets in the anomalies interpreted as due to the basalt flows appear to define accommodation zones trending towards the northeast. There is a more extensive discussion of this concept in Gunn et al. (1996a).

West Coast Sedimentary Basins

The sedimentary basins offshore from the west coast of Tasmania are collectively referred to as the Sorell Basin (Moore et al., 1992). The King Island (W1), Sandy Cape (W2) and Strahan (W3) Sub-basins of this area are covered by the aeromagnetic data and are evident as areas of lower-frequency anomalies due to increased depths to the pre-basin magnetic basement.

The magnetic patterns associated with the Sandy Cape and Strahan Sub-basins appear to indicate a series of normal faults trending in a northwesterly direction, and a conjugate series of accommodation zones trending in a northeasterly direction (similar to patterns in the Bass and Durroon basins). The King Island Sub-basin appears to be controlled by two parallel north-trending major bounding faults. These interpretations are discussed further by Gunn et al. (1996b).

Tasmania Basin (T)

The Tasmania Basin overlies much of central and southeastern Tasmania and in places contains at least 1300 metres of Carboniferous-Triassic sediments which have been intruded by large volumes of Jurassic dolerite. The dolerite cover has obscured basin structure and detail. The interpretation map of Figure 3 indicates several deep intrusions bounded by faults. These features must be classed as "possible" as they are not well defined in the magnetic data. The intrusions are best defined in the matched filtering image (Figure 5f), in which processing has heavily suppressed the effects of the dolerites. The remaining anomalies in the area of the Tasmania Basin appear to represent intrusive bodies although their apparent extents may have been broadened by the filtering process. These intrusions could be major feeders to the Jurassic dolerites, Cretaceous syenite intrusions or ultramafics associated with basement thrusting. Evidence for the faults shown comprises the rectangular boundaries of anomalies interpreted as due to the intrusions, and lineations apparent in the various magnetic images.

CONCLUDING REMARKS

This interpretation of the geographical distribution of the main basement elements of Tasmania is intended to provide a starting point for developing tectonic models for the development of Tasmania, which may in turn lead to conceptual ideas that could aid exploration in the state. Detailed analysis of specific features of the data will be required to elaborate fine detail. The interpretation map (Figure 3) will point to areas where such work is required.

Acknowledgments

The authors would like to thank Peter Hill and Aidan Moore for their discussion during the interpretation phase of the project and Peter Milligan and Oliver Raymond for their contructive comments on this paper.

This paper is published with the permission of the Executive Director of the Australian Geological Survey Organisation and the Director of Mines, Mineral Resources Tasmania.

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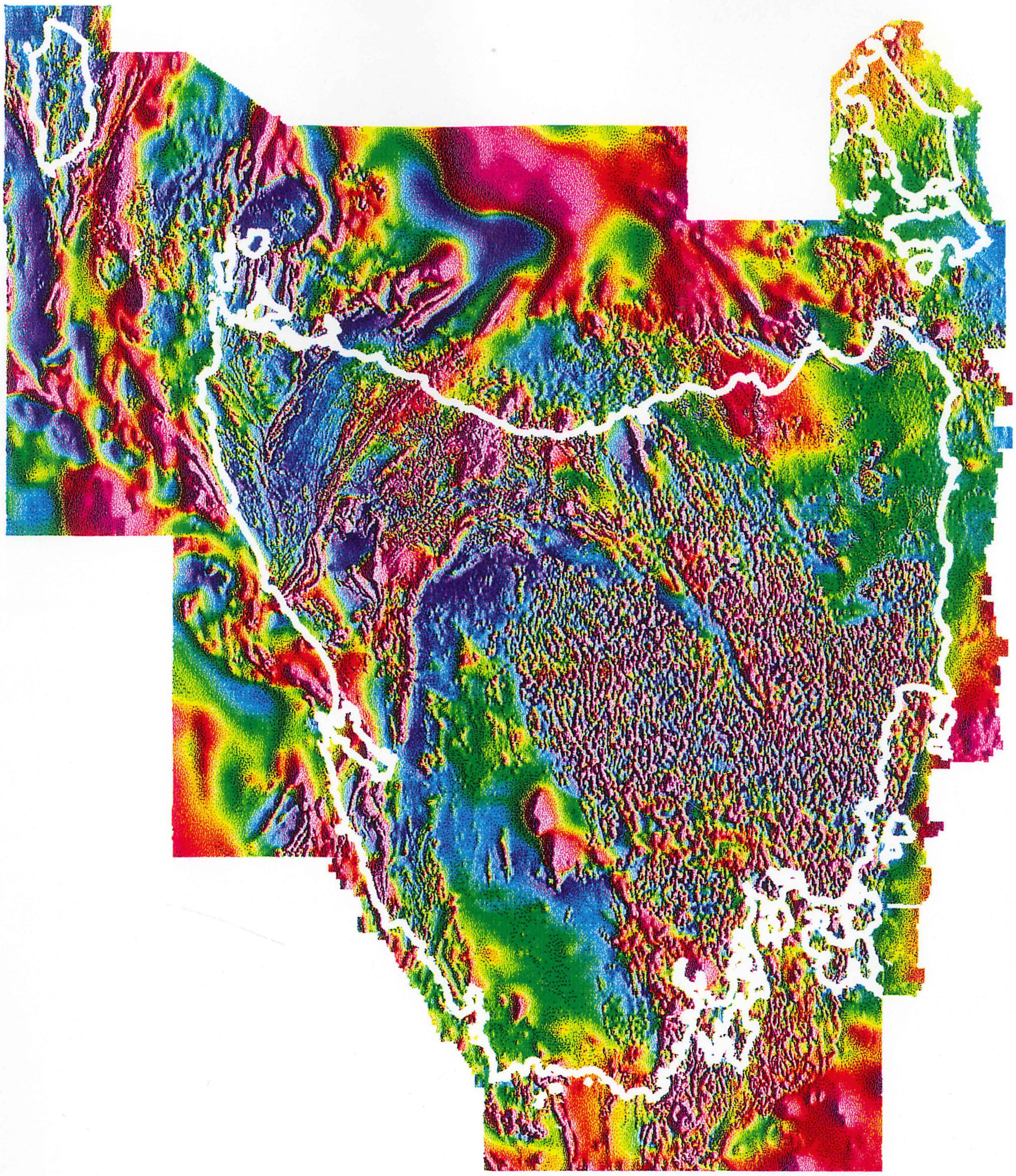
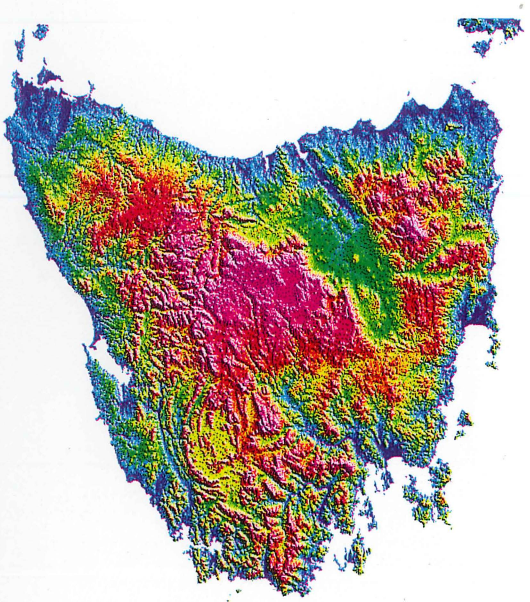


Figure 1: Colour TMI, with east-west gradient enhancement



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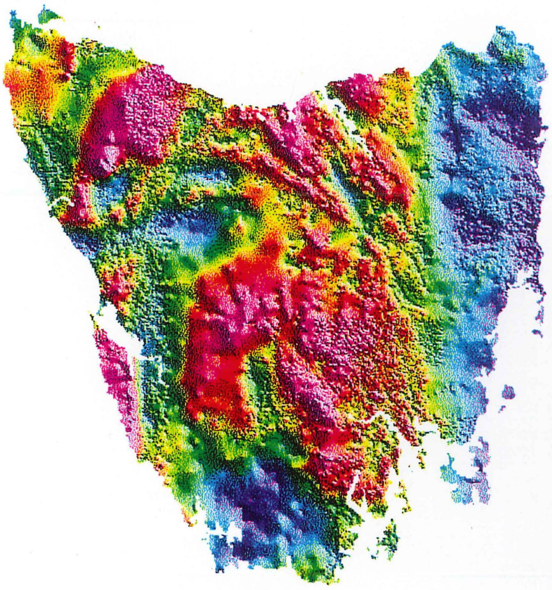

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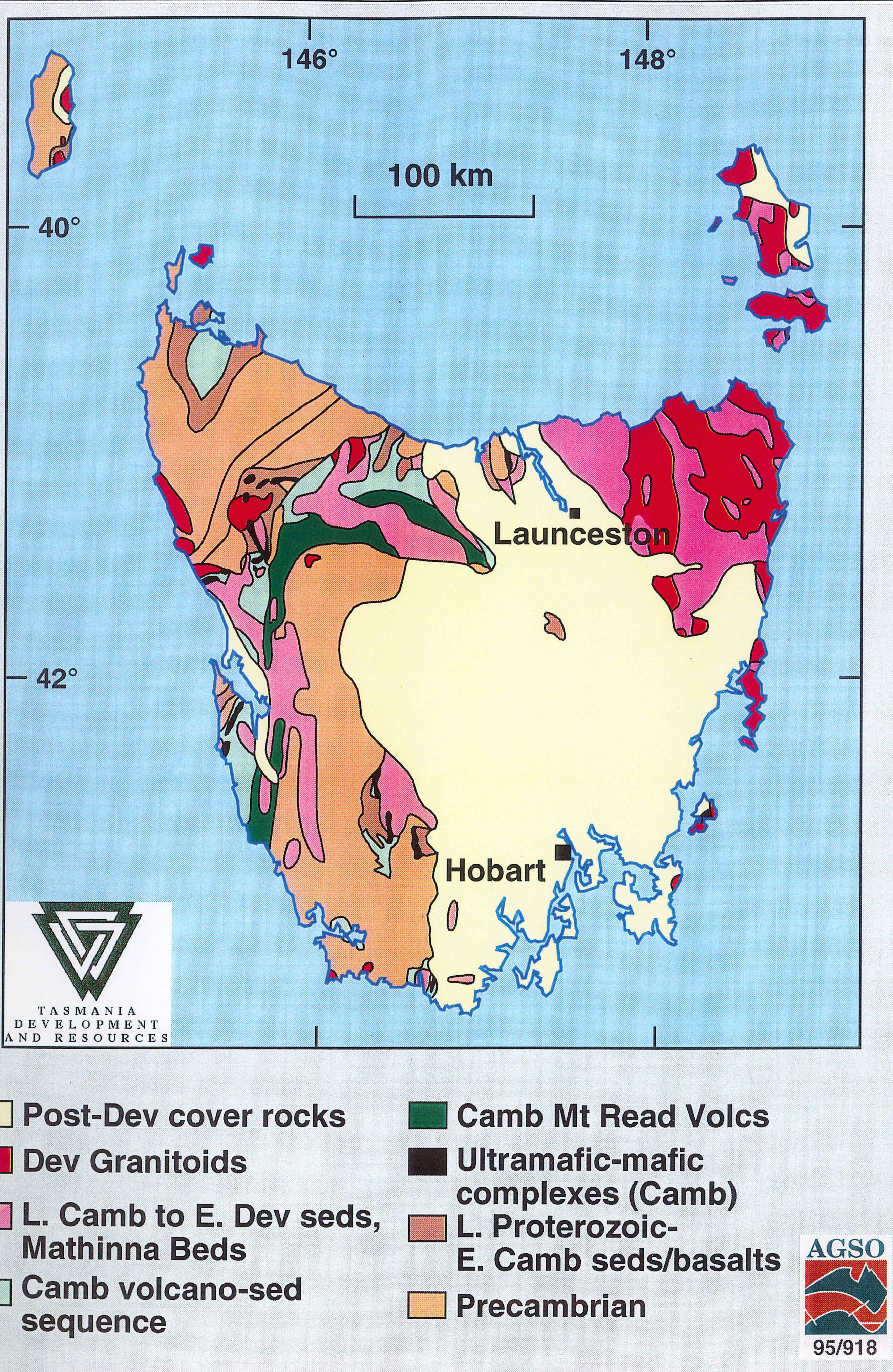
Figure 2. Regional Geology of Tasmania (modified from "Tasmania: Inviting investment in base and precious metals", Advertisement supplement to Mining Journal, London, 1994. Volume 322 No. 8264, page 6).



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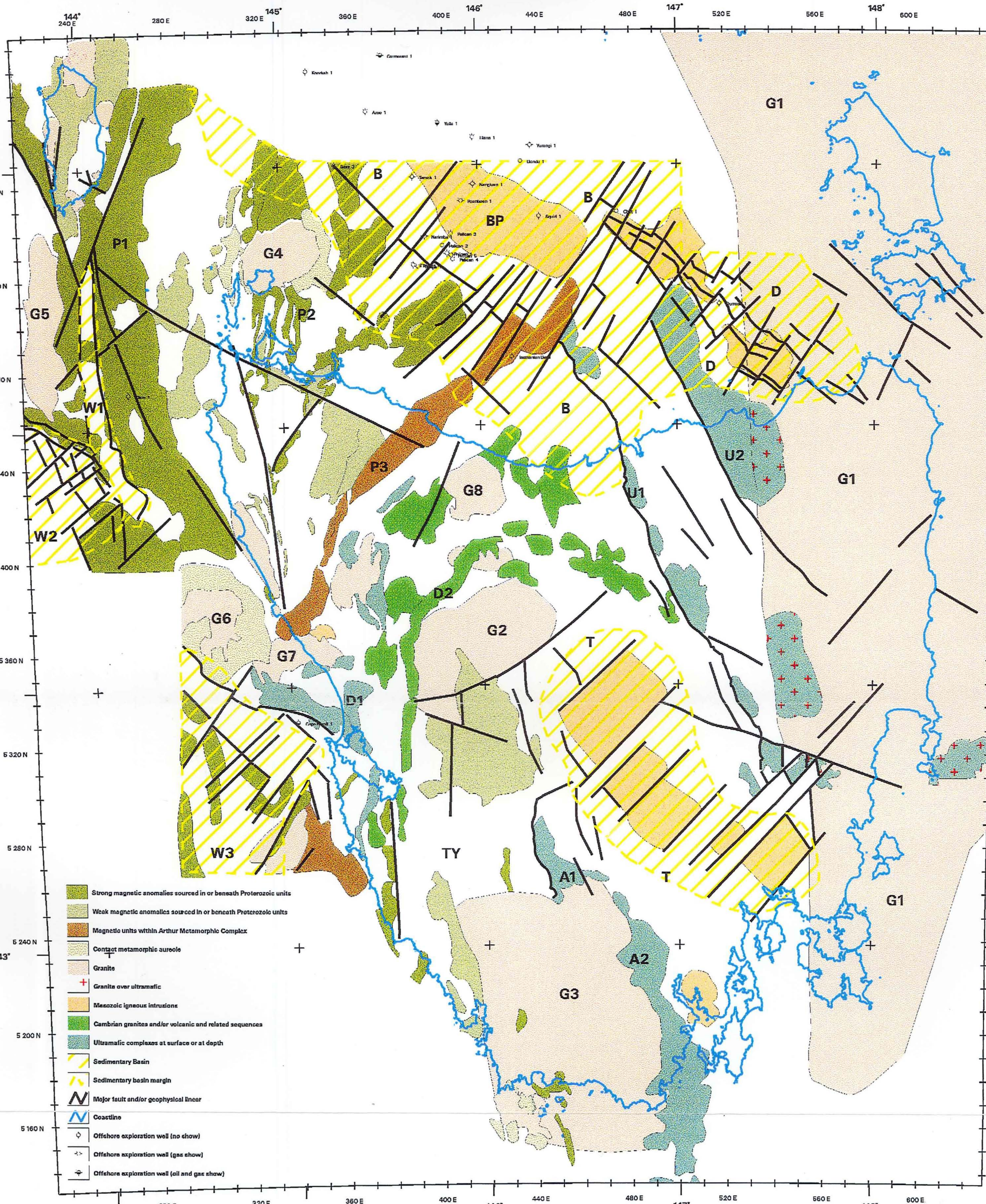

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GEOPHYSICAL MAPPING AIRBORNE GROUP

MAJOR BASEMENT ELEMENTS OF TASMANIA

INTERPRETED USING A COMBINATION OF KNOWN GEOLOGY, AEROMAGNETICS AND GRAVITY

20 0 20 40 60 80 100 km

TASMANIA DEVELOPMENT AND RESOURCES

Figure 3. Basement elements interpretation map

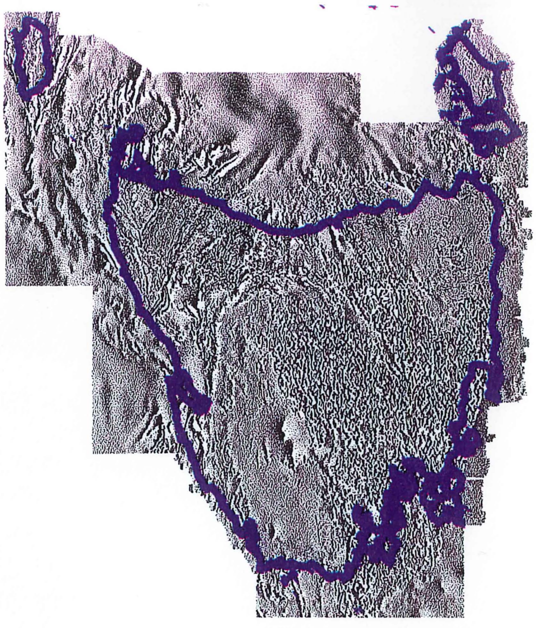


Figure 5a: Greyscale TMI with east-west gradient

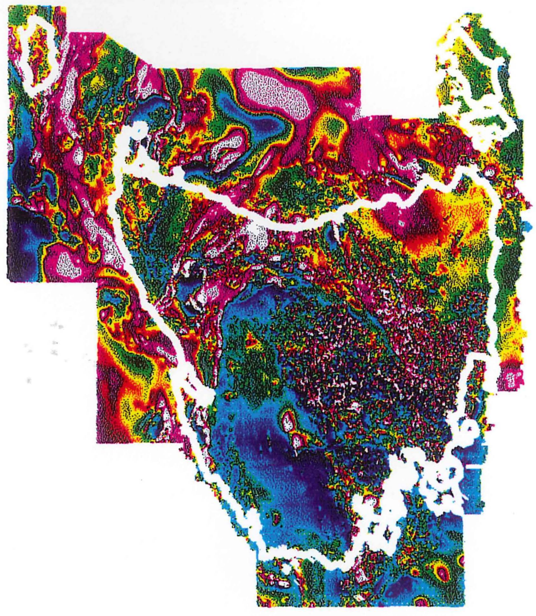


Figure 5b: Colour, histogram equalised TMI

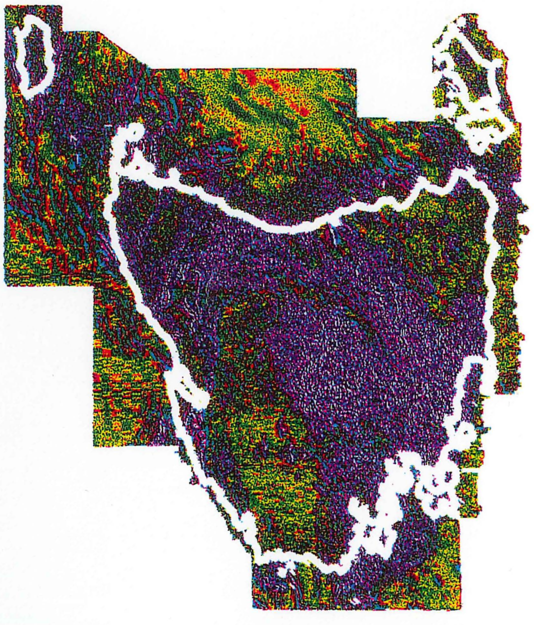


Figure 5c: Colour, first vertical derivative of TMI with northeast gradient

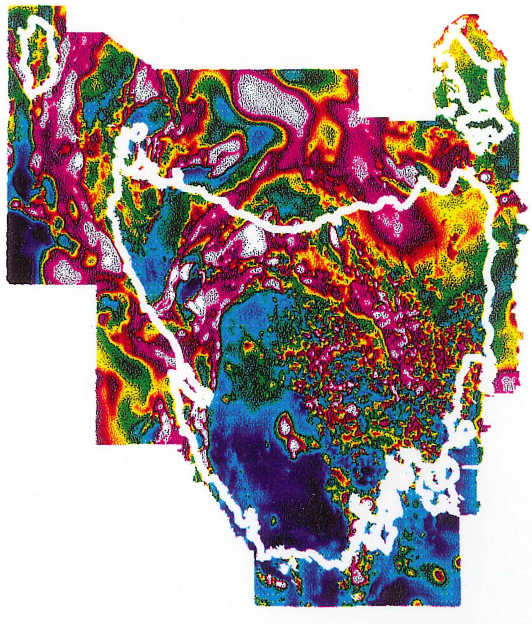


Figure 5d: Colour TMI, upward continued 1000 m

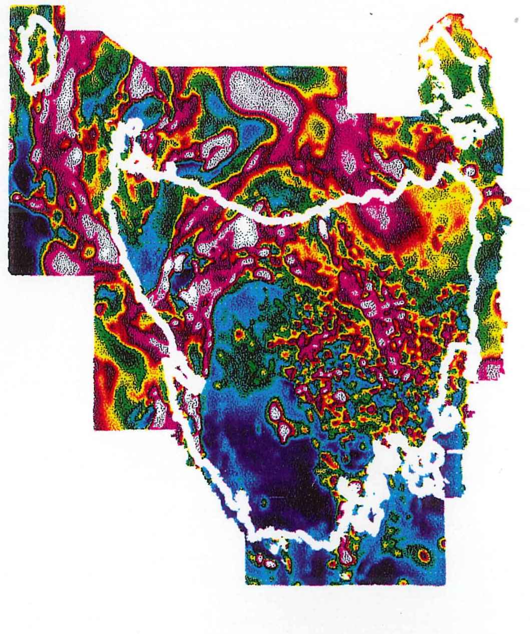
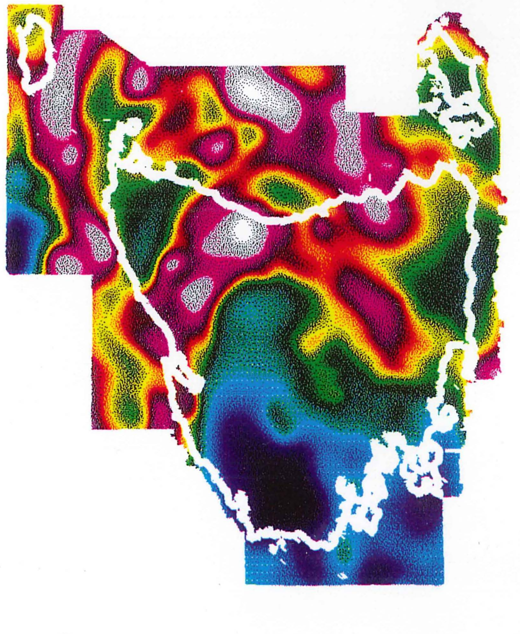


Figure 5e: Colour TMI, with wavelengths less than 5000 m removed



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