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Regional compilation and analysis of aeromagnetic anomalies for the Transantarctic Mountains–Ross Sea sector of the Antarctic

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Abstract

Magnetic observations over the area of the Transantarctic Mountains (TAM) and the Ross Sea have been compiled into a digital database that furnishes a new regional scale view of the magnetic anomaly crustal field in this key sector of the Antarctic continent. This compilation is a component of the ongoing IAGA/SCAR Antarctic Digital Magnetic Anomaly Project (ADMAP). The aeromagnetic surveys total 115 000 line km, and are distributed across the Victoria Land sector of the TAM, the Ross Sea, and Marie Byrd Land. The magnetic campaigns were performed within the framework of the national and international Italian–German–US Antarctic research programs and conducted with differing specifications during nine field seasons from 1971 until 1997. Generally flight line spacing was less than 5 km while survey altitude varied from about 610 to 4000 m above sea level for barometric surveys and was equal to 305 m above topography for the single draped survey. Reprocessing included digitizing the old contour data, improved levelling by means of microlevelling in the frequency domain, and re-reduction to a common reference field based on the DGRF90 model. A multi-frequency grid procedure was then applied to obtain a coherent and merged total intensity magnetic anomaly map. The shaded relief map covers an area of approximately 380 000 km^2. This new compilation provides a regional image of the location and spatial extent of the Cenozoic alkaline magmatism related to the TAM–Ross Sea rift, Jurassic tholeiites, and crustal segments of the Early Palaeozoic magmatic arc. A linear, approximately 100-km wide and 600-km long Jurassic rift-like structure is newly identified. Magnetic fabric in the Ross Sea rift often matches seismically imaged Cenozoic fault arrays. Major buried onshore pre-rift fault zones, likely inherited from the Ross Orogen, are also delineated. These faults may have been reactivated as strike-slip belts that segmented the TAM into various crustal blocks.

Keywords: Antarctica; Magnetic anomalies; Tectonic structures; Magmatism; Geomagnetism

1. Introduction

Remotely sensed magnetic anomaly data provide an important means for obtaining geological information over much of the ice covered Antarctic continent to help delineate major crustal domains, such as cratons, accreted terranes, mobile belts and rift systems. Consequently, the international community has carried out numerous near-surface magnetic surveys for site-specific geologic objectives (Chiappini et al., 1999a). Individual magnetic surveys can be combined into regional and ultimately

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continent-wide compilations for the Antarctic to greatly enhance their geologic utility in a similar fashion, as has been done for other regions of the world like Australia (Tarlowski et al., 1996) and the Arctic (Macnab et al., 1995).

Within the framework of ADMAP, an international consortium called INtegrated Transantarctic Mountains Ross Sea Area Magnetic Anomaly Project (INTRAMAP) was launched (Johnson et al., 1996; Chiappini et al., 1998, 1999a,b) to compile and integrate into a digital database all near-surface and satellite magnetic anomaly data (Fig. 1) south of 60°S within the Antarctic sector 135–255°E. As a major development of this project, we present the compilation of aeromagnetic anomaly data within the sector 155–215°E. Also considered here is the production of this map involving the acquisition of all available digital aeromagnetic data sets in the region and digitizing of contour data, re-processing of individual surveys, and the merging of the individual surveys.

The new magnetic anomaly compilation for the Antarctic sector features significant regional geologic components of the continent that differ in age and tectonic setting (Fig. 4). These components include the eastern edge of the Precambrian East Antarctic Craton (Oliver and Fanning, 1997), the Ross Orogen (Stump, 1995), the Jurassic Ferrar Magmatic Province (Elliot, 1992), the Transantarctic Mountains (TAM) rift shoulder (Fitzgerald et al., 1986; Stern and ten Brink, 1989; Fitzgerald and Baldwin, 1997; ten Brink et al., 1997), and a significant part of the West Antarctic Rift System (Behrendt et al., 1992). The regional magnetic signatures of these components in the compiled map are also identified and discussed.

2. Magnetic surveys

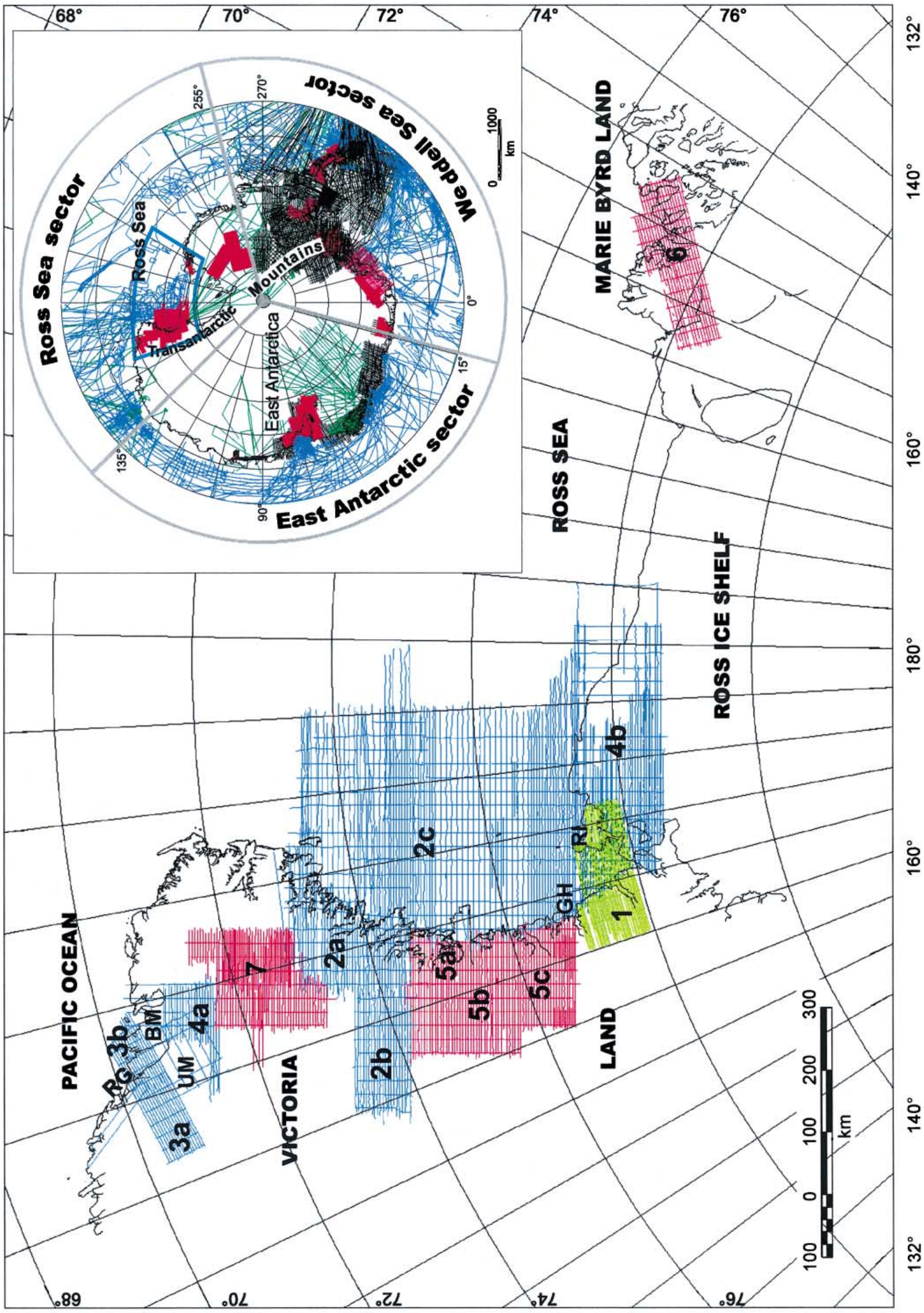
2.1. US program

Aeromagnetic exploration of the Transantarctic Mountains and the adjacent Ross Sea by the US program began in the 1960s with widely spaced and poorly located profiles (Behrendt and Bentley, 1968). An aeromagnetic survey at a line spacing of 5 km over Ross Island (RI in Fig. 1) yielded an unpublished total intensity map (Robinson, 1964). In the period 1971–1973, another aeromagnetic survey was obtained over Ross Island and the Taylor Valley area (Fig. 2a,b) that was only recently digitized (Finn et al., 1999, written communication). The "Taylor" survey, which is indicated in Fig. 1 by 1, was flown draped with an average terrain clearance of 305 m and at a line spacing of 2 km using a Varian M-50 nuclear precession magnetometer (Pederson et al., 1981). Navigation relied on radio signals and visual sightings of topographic features, so that positional accuracies of 0.5–1 km were obtained.

2.2. GANOVEX program

Much later, the German Antarctic North Victoria Land Expedition (GANOVEX) surveys achieved regional magnetic coverage across the Transantarctic Mountains, McMurdo Sound and part of the Ross Sea. These fixed-wing and helicopter-borne magnetic surveys were generally flown with a line spacing of 4.4 km during the period 1984–1991 (Surveys 2, 3, 4a, b in Fig. 1). The GANOVEX IV involved three campaigns (Damaske, 1988) where the TAM section (2a in Fig. 1) was flown at 4000 m, the Polar Plateau section at 3000 m (2b in Fig. 1), and the Ross Sea (2c in Fig. 1)

Fig. 1. Distribution of the aeromagnetic data profiles that were reprocessed and compiled within the framework of the INTRAMAP project for the Transantarctic Mountains–Ross Sea–Marie Byrd Land area. The lines are numbered and colored to indicate: (1) the "Taylor" survey flown in the period 1971–1973 over Ross Island and the Dry Valleys (green); (2) the GANOVEX IV survey carried out in the 1984/85 field season (blue); (3) the GANOVEX V survey flown during the 1988/89 expedition (blue); (4a–b) aeromagnetic lines acquired during the GANOVEX VI expedition of 1990/91 over the Bowers Mountains and the Ross Ice Shelf areas respectively (blue); (5a–b–c) the GITARA surveys in Central Victoria Land flown during 1991/94 field seasons (red); (6) the joint GITARA–GANOVEX effort over Marie Byrd Land in 1992/93 (red); and (7) the most recent GITARA survey in Northern Victoria Land (red). Feature abbreviations include: BM (Bowers Mountains); GH (Granite Harbour); RG (Rennick Glacier); RI (Ross Island); and UM (USARP Mountains). The inset shows the track chart for the Antarctic region south of 60°S. Colors of the aeromagnetic paths roughly represent line spacing: red (< 5 km), black (~ 20 km), and green (> 50 km). Marine lines are in blue.


PACIFIC OCEAN
VICTORIA
LAND
ROSS SEA
ROSS ICE SHELF
MARIE BYRD LAND
Ross Sea sector
Weddell Sea sector
East Antarctic sector
Ross Sea
Transantarctic
Mountains
East Antarctica
km
0
100
200
300
1000
3a
3b
4a
4b
2a
2b
2c
5a
5b
5c
1
6
7
RG
BM
UM
GH
RI

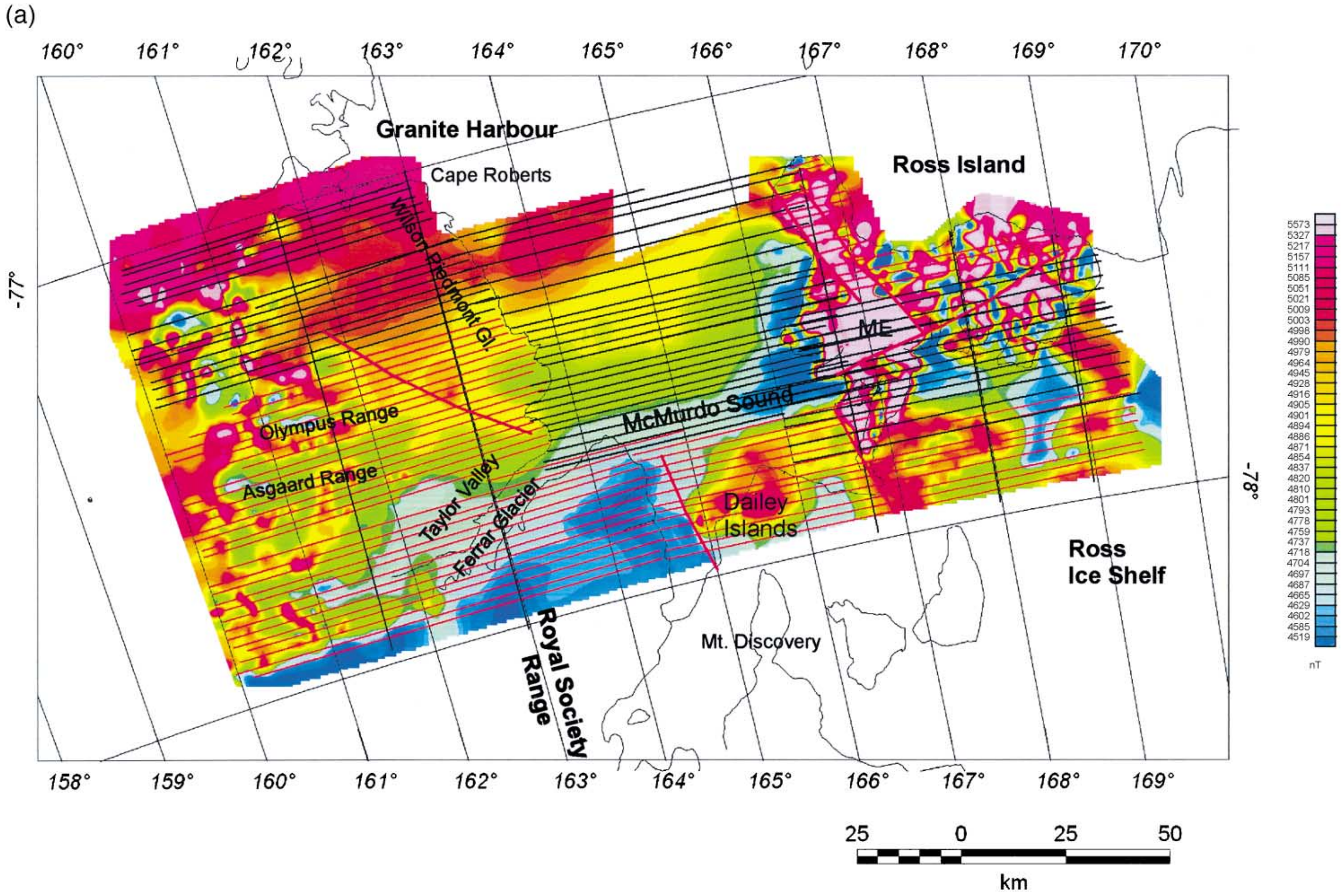


Fig. 2. (a) Original grid for the old ''Taylor'' aeromagnetic survey flown over Ross Island and the Dry Valleys that was obtained by digitizing the contour data and subtracting a datum of 60,000 nT. Red lines identify possible magnetic trends. Note the NW trend separating apparent magnetic basement beneath the Wilson Piedmont Glacier from higher frequency anomalies over the Jurassic dolerites of the Olympus and Asgaard Range. High-amplitude anomalies are also observed over the active Mount Erebus volcano (ME). (b) The anomaly grid obtained after reprocessing the ''Taylor'' aeromagnetic data set in (a). Relative to the results in (a), the basement at the Ross Sea coast beneath the Wilson Piedmont Glacier now appears virtually nonmagnetic, but the higher frequency magnetic anomalies over the Jurassic dolerites and Cenozoic volcanics are preserved.

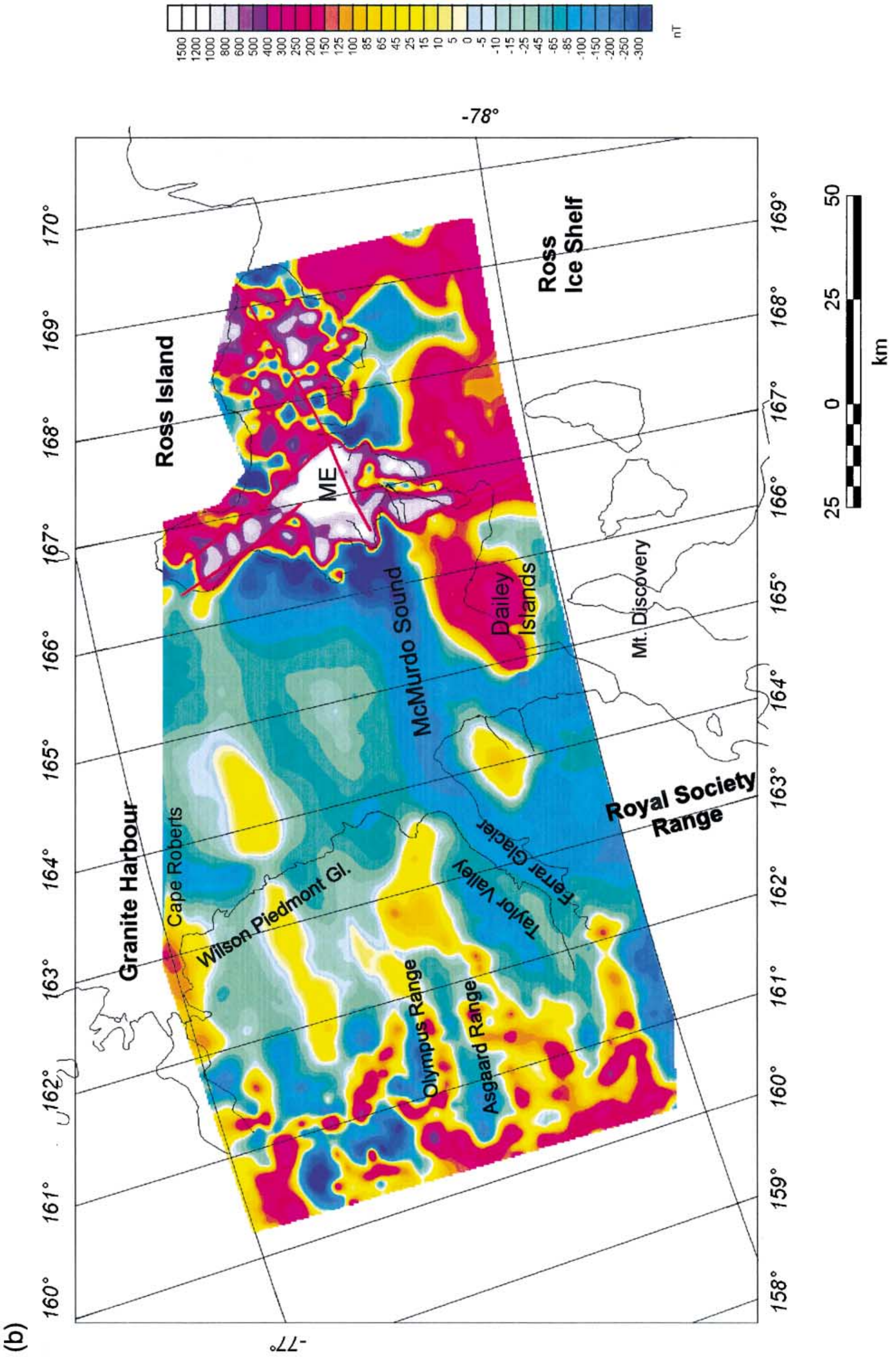


Fig. 2 (continued).

at 610 m a.s.l. (Bachem et al., 1989). Magnetic anomaly maps were compiled at 1:250 000 scale from the processed data sets (BGR and USGS 1987) and interpretation of the anomalies revealed contrasting tectonic units both along the TAM rift flank and within the Ross Sea rift (Bosum et al., 1989).

The GANOVEX V survey (Damaske and Bosum, 1993) covered the northern part of the Rennick Glacier (RG in Fig. 1) adjacent to the Bowers Mountains (BM in Fig. 1), and the USARP Mountains (UM in Fig. 1). The two sections were flown at altitudes of 1220 and 2700 m, respectively. A magnetic anomaly map at 1:250 000 scale was prepared from this survey (Damaske, 1990). During the GANOVEX VI (Damaske, 1996), two sectors were flown over the northwestern Ross Ice Shelf (flight altitude 610 m) and the Bowers Mountains (flight altitude 2700 m) and mapped (Damaske and Behrendt, 1996; Damaske and Finn, 1996).

Table 1
Catalogue of the aeromagnetic surveys that were reprocessed and compiled by the INTRAMAP project for the TAM–Ross Sea sector (updated from Chiappini et al., 1999a)

GITARA 1, 2, 3, 5
Location: Victoria Land, Marie Byrd Land
Type: Helicopterborne
Date: 1991–1997
Line spacing: 4.4 and 2.2 km (tie lines 22 km apart)
Survey height: 2700 m
Magnetometer: Caesium, towed bird configuration
Line km: 31,000
Navigation: Beacon, GPS, DGPS
Navigation accuracy: 50–10 m
Countries: Italy, Germany
Funding: PNRA, BGR
GANOVEX IV, V, VI
Location: Ross Sea, McMurdo Sound, Northern Victoria Land
Type: Airborne and helicopterborne
Date: 1984–1993
Line spacing: 4.4 and 8.8 km (tie lines 22 km apart)
Survey height: 3660–2700–1220–610 m
Magnetometer: Proton precession (wingtip), caesium, towed bird
Line km: 72,000
Navigation: Doppler, Beacon, INS, GPS
Navigation accuracy: 100–50 m
Countries: Germany, USA
Funding: BGR, AWI, NSF
TAYLOR
Location: McMurdo Sound–Ross Island–Dry Valleys
Type: Helicopterborne
Date: 1971–1973
Line spacing: 2.0 km
Survey height: 305 m draped
Magnetometer: Nuclear precession, towed bird configuration
Line km: 9,390
Navigation: Radio signals, visual
Navigation accuracy: 0.5–1 km
Countries: USA

2.3. GITARA program

Between 1991 and 1997, five helicopter surveys (labeled 5a, 5b, 5c, 6, and 7 in Fig. 1) were carried out by the German–Italian Aeromagnetic Research in Antarctica (GITARA) campaigns. The flight altitude over the TAM was 2700 m (Bozzo et al., 1997a,b, 1999), while over northwestern Marie Byrd Land it was 2000 m (Damaske et al., 2002). The GITARA 4 aeromagnetic survey (Bozzo et al., 1997c), a high-resolution low-altitude survey performed offshore over Granite Harbour (GH in Fig. 1) was not included in the regional compilation. The latest campaign, GITARA 5 (Bozzo et al., 1999), linked the previous surveys at the Pacific Coast with those at the Ross Sea coast. It was flown during the 1996–97 field season and imaged the central part of the Rennick Graben and the Northern Victoria Land terrane boundaries (Fig. 4).

Additional data from ground magnetic observations were collected in the Terra Nova Bay region during four Italian expeditions (1985–1989). These data provide ground control for local aeromagnetic anomalies and the diverse magnetic properties of the region for geologic interpretation (Bozzo and Meloni, 1992). A catalogue of the aeromagnetic data used for the magnetic anomaly compilation is given in Table 1.

3. Map compilation procedures

An ideal magnetic anomaly compilation improves the signal-to-noise ratio of individual data sets, ensures a smooth transition from one data set to the other, and maintains the correct amplitude and spectral integrity of the magnetic signals in the final map. The signal-to-noise ratio of the original aeromagnetic surveys normally is related to the navigation quality and the accuracy in removing time-dependant magnetic field variations by base-station corrections and levelling procedures. The positional accuracy for the compiled data (Table 1) ranged from about 1 km for the early surveys that were visually navigated to about 10 m for the more recent surveys controlled by differential GPS navigation. For the early surveys, little could be done to improve the navigation data, except to check for possible spikes, errors and missing lines due to archiving problems. However, the overall quality of the compilation could be improved by applying a coherent reference field model and improved levelling procedures to the survey data.

3.1. Taylor survey data processing

The relatively low-resolution data from the Taylor survey were initially digitized where contours crossed flight lines spaced roughly 2 km apart and at the inflection points of contours (Finn et al., 1999, written communication). The digitized data were gridded (Fig. 2a) using the minimum curvature method at a grid interval of 1 km. Further processing included adding back the datum of 60 000 nT and a gradient of 5 nT/km to the north–northwest that had been removed in the original data processing (Pederson et al., 1981). The reference field using the DGRF90 coefficients (Barton et al., 1996) was then removed.

The leveling of the original Taylor survey data was problematic owing to navigation errors and the use of only three tie lines. Possible leveling artifacts that we noted included N–S gradients across the flight lines and some offsets between adjacent lines. We therefore constructed pseudo-profiles and pseudo-tie lines, sampled the original grid along them and then manually applied level shifts and first order trends where appropriate. The anomaly field was finally micro-levelled to minimize further the residual flight line-related noise (Ferraccioli et al., 1998).

The final results are shown in Fig. 2b. As an example of the positive effects of the reprocessing, note the change between Fig. 2a and b in the regional magnetic high over the Wilson Piedmont Glacier region relative to the negative anomaly field south of the Ferrar Glacier. In Fig. 2a, these features suggest that basement to the north may be considerably more magnetic than to the south, while in the reprocessed image of Fig. 2b both areas appear to feature mostly nonmagnetic basement. The latter interpretation is much more consistent with the rock susceptibility data (Pederson et al., 1981).

3.2. GANOVEX and GITARA data processing

The original aeromagnetic data were base-station corrected, but levelled using different strategies. The GANOVEX data were levelled by least squares techniques, while GITARA data leveling relied on a statistical approach. No major re-levelling efforts were undertaken for these surveys, but microlevelling in the frequency domain was applied (Ferraccioli et al., 1998). This required filtering parameters to be tuned according to the flightline noise, spacing and orientation. For the GITARA 3 survey, a set of previously unprocessed survey lines were also included resulting in a higher resolution line spacing of 2.2 km over the Convoy Range–Allan Hills region (CR–AH in Fig. 4) of Southern Victoria Land. After removing the DGRF90, the whole GITARA and GANOVEX data set was re-levelled, resulting in an improved link between the Transantarctic Mountains, the Polar Plateau and the Ross Sea sections (Chiappini et al., 1999b).

3.3. Survey integration

To integrate the re-processed survey data, we first projected them at a common Lambert Conformal projection (Table 2) then re-gridded at an interval of 880 m, which represented roughly 1/5 the mean line spacing. The gridding was performed by the minimum curvature method with a radius of influence of 6 km. Magnetic anomalies in the overlapping regions of the surveys may differ in base levels, mean values, amplitudes, phases and wavelengths even when processed by common procedures. These discrepancies were

Table 2
Parameters for the Lambert Conformal projection

Projection	Lambert Conformal
Spheroid	WGS 1972
Central meridian	179
Base parallel	− 74.0181118
Southern parallel	− 75.3333333
Northern parallel	− 72.6666667
False easing	1,444,000
False northing	1,123,000

observed for (a) different surveys flown at approximately the same altitude and line spacing (e.g. Polar Plateau section of the GANOVEX IV and the GITARA surveys, 5a, b in Fig. 1), (b) different parts of the same survey flown at different altitude (e.g. the Polar Plateau and Rennick Glacier section of GANOVEX V), and (c) different surveys also flown at different altitudes.

To handle situation (a), we first added a constant value (DC level shift) to the survey with lowest apparent resolution and then applied an interactive multi-frequency FFT grid suturing method (Johnson et al., 1999). With this method corrections were spread over the magnetic anomaly grids in proportion to the wavelengths of the mismatching anomalies in the overlapping regions. In the grid merging process, the greatest weights were assigned to the more modern GITARA surveys.

For situations (b) and (c), only simple levelling was applied. Additional improvements may be possible from analytical continuations of the individual surveys, or draping them on the topographic surface. However, our analytical continuations yielded problematic results and hence were not adopted. For example, considerable detail in the magnetic anomaly patterns over the rift system was lost by the upward continuation of the Ross Sea anomaly data to the elevations of the Transantarctic Mountains survey data. Downward continuation, on the other hand, introduced spurious short wavelength features in the Transantarctic Mountains survey data even after considerable smoothing was applied (Chiappini et al., 1999b).

Draping over the topographic surface also was not implemented because the sub-ice magnetic topography is largely unknown. This problem greatly complicated anomaly-draping efforts for the Rennick Glacier and David Glacier regions (Fig. 4), and along the eastern margin of the subglacial Wilkes Basin (inset in Fig. 5).

The final compilation of magnetic anomalies is shown in Fig. 3. The implemented levelling will introduce ambiguities in quantitative analysis of the anomalies if the displacement distances to the sources are not adequately taken into account. However, the processing minimized distortions of the original signals and produced a map that is coherent with the one obtained for the East Antarctic sector (Golynsky et al., 2002). Overall, the individual survey grids in Fig. 3 are joined reasonably well with minimal edge effects. Locally, some high frequency trends were lost (Chiappini et al., 1999b), but good regional continuity of anomaly amplitudes and wavelengths was generally obtained.

4. Tectonic implications of the magnetic anomaly compilation

The magnetic survey compilation (Fig. 3) presents a synoptic view of anomalies and their associations with regional geologic features of the Transantarctic Mountains and Ross Sea (Fig. 4) that was not possible from the individual surveys. To facilitate the discussion, the magnetic anomalies were labelled and superimposed on the simplified tectonic sketch map presented in Fig. 5. Our synthesis of the main magnetic features of the study region is presented in Fig. 6.

4.1. The eastern edge of the Precambrian East Antarctic Craton and the Ross Orogen

The exposed basement of the Transantarctic Mountains (TAM) reflects an Early Paleozoic mountain belt of the Ross Orogen that formed in a contractional tectonic regime (Goodge, 1995). Older Precambrian crust of the East Antarctic Craton (EAC) recognized over George V Land (Oliver and Fanning, 1997) does not outcrop further to the east over Victoria Land, although model ages seem to support its existence at depth (Borg and DePaolo, 1994; Rocchi et al., 1998). The basement is subdivided as shown in Fig. 4 into the Robertson Bay Terrane (RBT), the Bowers Terrane (BT) and the Wilson Terrane (WT) (Bradshaw, 1989). The RBT and the BT feature very low-grade to low-grade metasedimentary and metavolcanic rocks of Cambrian–Ordovician age, while the WT also includes high-grade rocks (Talarico et al., 1992).

A subduction-to-collision-driven accretion of the BT and RBT to the active margin of the EAC at about 500 Ma has been inferred from high-pressure mafic–ultramafic rocks along the WT–BT boundary, the intra-oceanic island-arc geochemistry of the BT volcanic rocks, continental arc-related magmatism (Granite Harbour Intrusives) within the WT, and by the structural architecture of the basement thrust faults

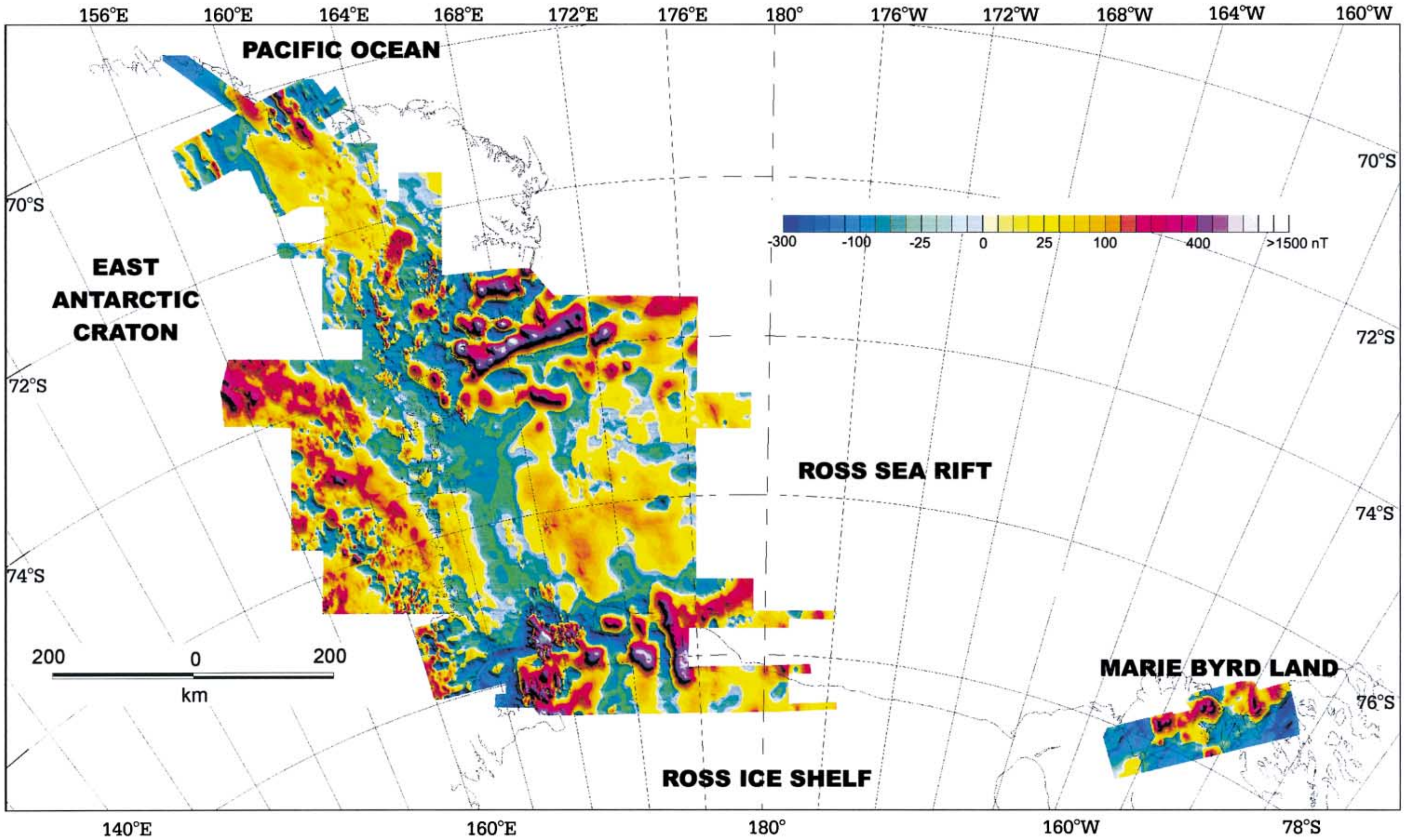
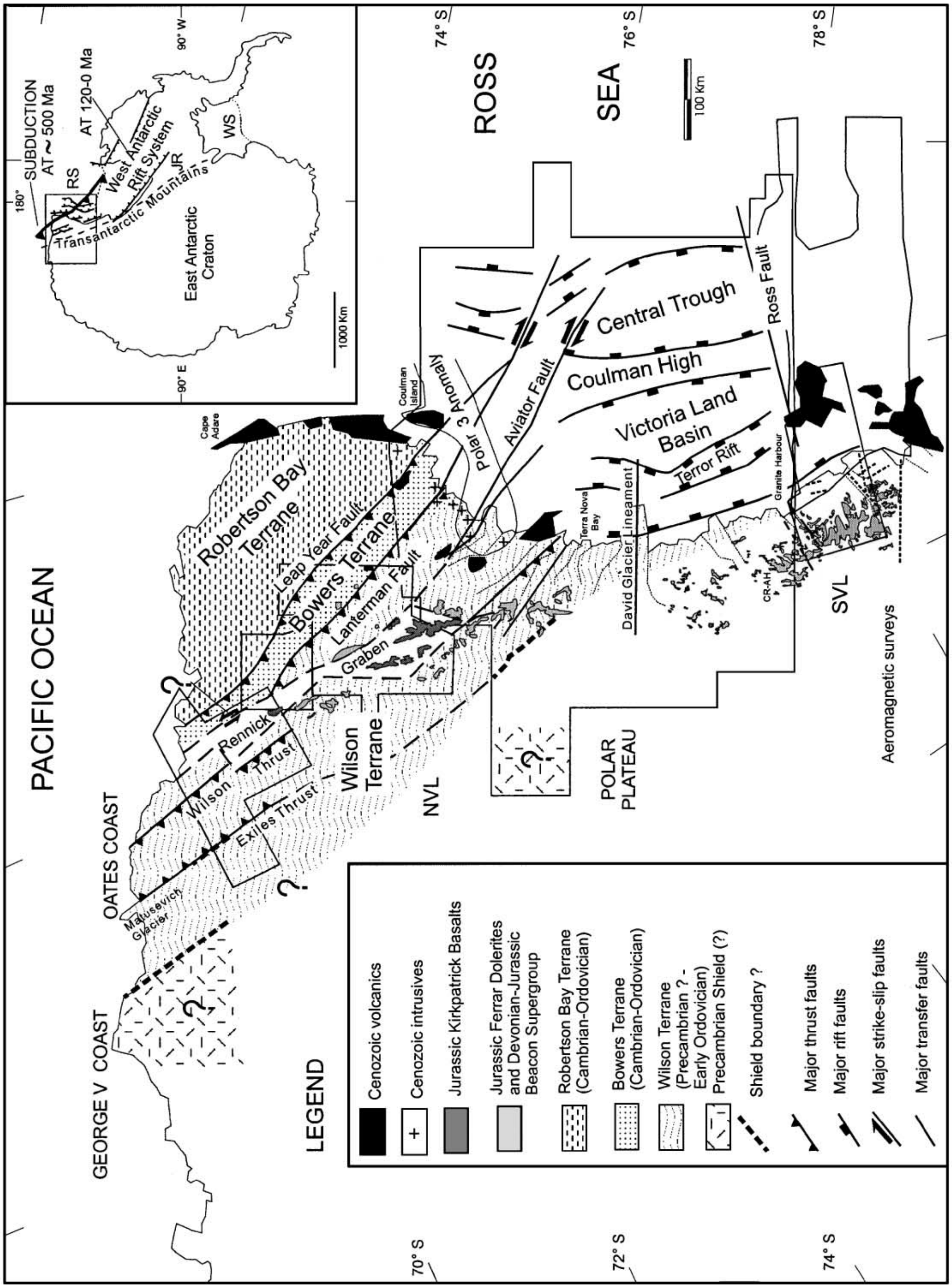


Fig. 3. Shaded relief map of the merged total field magnetic anomalies for the INTRAMAP sector.


PACIFIC OCEAN
ROSS
SEA
100 Km
OATES COAST
GEORGE V COAST
Matusevich Glacier
Robertson Bay Terrane
Bowers Terrane
Wilson Terrane
Leap Year Fault
Lanterman Fault
Graben
Rennick
Wilson
Thrust
Exiles Thrust
NVL
SVL
POLAR PLATEAU
Cape Adare
Coulman Island
Polar 3 Anomaly
Aviator Fault
Coulman High
Central Trough
Victoria Land Basin
Terror Rift
Ross Fault
Terra Nova Bay
David Glacier Lineament
Granite Harbour
CR-AH
Aeromagnetic surveys
150° E
160° E
170° E
180° E
70° S
72° S
74° S
76° S
78° S
SUBDUCTION AT ~ 500 Ma
AT 120-0 Ma
RS
JR
WS
West Antarctic Rift System
Transantarctic Mountains
East Antarctic Craton
1000 Km
180°
90° W
90° E
LEGEND
Cenozoic volcanics
Cenozoic intrusives
Jurassic Kirkpatrick Basalts
Jurassic Ferrar Dolerites and Devonian-Jurassic Beacon Supergroup
Robertson Bay Terrane (Cambrian-Ordovician)
Bowers Terrane (Cambrian-Ordovician)
Wilson Terrane (Precambrian ? - Early Ordovician)
Precambrian Shield (?)
Shield boundary ?
Major thrust faults
Major rift faults
Major strike-slip faults
Major transfer faults

(e.g. Kleinschmidt and Tessensohn, 1987; Ricci et al., 1997). However, the timing and modes of terrane accretion are widely debated.

The magnetic signature of the Ross Orogen can be used to further constrain its structure and nature where it is not overprinted by recent tectonic and magmatic events. However, at the Ross Sea coast, no clear magnetic signature is evident for the suture zone between the WT and the BT (Bosum et al., 1989; Bozzo et al., 1995). In the Terra Nova Bay area, ground magnetic and aeromagnetic anomalies (TNB in Fig. 5) are evident over the magnetite-rich Granite Harbour Intrusives (Bozzo and Meloni, 1992).

The long-wavelength positive magnetic anomaly to the west of the Central Victoria Land Boundary (GAC in Fig. 5) has been related to buried Ross-age intrusives emplaced in a back-arc (Ferraccioli and Bozzo, 1999). An earlier interpretation, by contrast, related part of this anomaly to Precambrian shield crust (Bosum et al., 1989). The more recent interpretation also suggests that the magnetic boundary may image the buried continuation of the Exiles Thrust (EX in Fig. 5).

Over the northern Rennick Glacier region, a chain of high amplitude positive anomalies (R in Fig. 5) has been interpreted as evidence for oceanic forearc crust beneath the Bowers Terrane (Finn et al., 1999). Comparison with similar magnetic signatures from younger subduction zones in California and Japan suggests that current terrane accretion models for this region may be quite limited (Finn et al., 1999). Our map shows the high-amplitude magnetic anomaly (SR in Fig. 5) over the partially outcropping Devonian–Carboniferous Admiralty Intrusive cut by the Lanterman Fault (i.e., the WT–BT boundary). Therefore, the WT must have been adjacent to the BT from at least the Devonian. Until now, the presence of this intrusion across the WT–BT boundary was controversial (Borg and Stump, 1987; Fioretti et al., 1997).

4.2. Extent of the Jurassic Ferrar tholeiites

Denudation of the Ross Orogen formed the Kukri Peneplain, which is the regional erosion surface separating the basement from the cover rocks (Gunn and Warren, 1962). Devonian to Jurassic deposition of the continental Beacon Supergroup occurred in intracratonic or foreland basins parallel to the ancestral paleo-Pacific margin (Collinson, 1997; Woolfe and Barrett, 1995). In the Jurassic, widespread extrusion and intrusion of tholeiitic rocks (Kirkpatrick Basalt and Ferrar Dolerite) then occurred at the EAC margin, possibly along a volcano–tectonic rift zone (Wilson, 1993).

The individual surveys provided limited local information on the distribution of Jurassic tholeiites. For example, the Taylor survey indicated the presence of these rocks in the Olympus Range and Asgaard Range (Fig. 2a,b) in Southern Victoria Land (Pederson et al., 1981). Later GITARA surveys revealed the extent of the Jurassic rocks in the Prince Albert Mountains (PAB in Fig. 5) along a seismic transect (Ferraccioli et al., 1997). A similar magnetic pattern at the edge of the Polar Plateau may reflect basaltic rocks totally covered by ice (Bosum et al., 1989).

In the compilation, the newly recognized regional continuity of a positive linear magnetic anomaly (JR in Fig. 5) is evident for an approximately 100-km-wide by 600-km-long region that may reflect a Jurassic rift. The higher resolution data over the Convoy Range–Allan Hills region (CR–AH in Fig. 4) enhance NNE to NE magnetic trends that may possibly represent younger faults within this linear zone dominated by flood basalts.

Fig. 4. Major geologic features of the INTRAMAP sector with superimposed aeromagnetic survey boundaries (modified from Ferraccioli and Bozzo, 1999). Regional thrust faults are recognized from geologic data within the basement terranes of Victoria Land and rift-related faults are interpreted from seismic data over the Ross Sea. Possible strike-slip and transfer faults (e.g. the David Glacier Lineament) are also reported. Dashed lines mark inferred faults bounding the Rennick Graben and faults to the south of Granite Harbour. The inset depicts features of the tectonic evolution of the Transantarctic Mountains region that may be addressed by the magnetic anomaly compilation. These include: (a) the subduction beneath the Precambrian East Antarctic Craton at about 500 Ma during the Ross Orogen; (b) the Jurassic tholeiites related to possible rifting in the TAM; (c) the rift phases within the West Antarctic Rift System from 120 Ma to the present. Feature abbreviations include: CR-AH (Convoy Range-Allan Hills region); JR (Jurassic Rift of the Ferrar Magmatic Province); NVL (Northern Victoria Land); RS (Ross Sea); SVL (Southern Victoria Land); and WS (Weddell Sea).

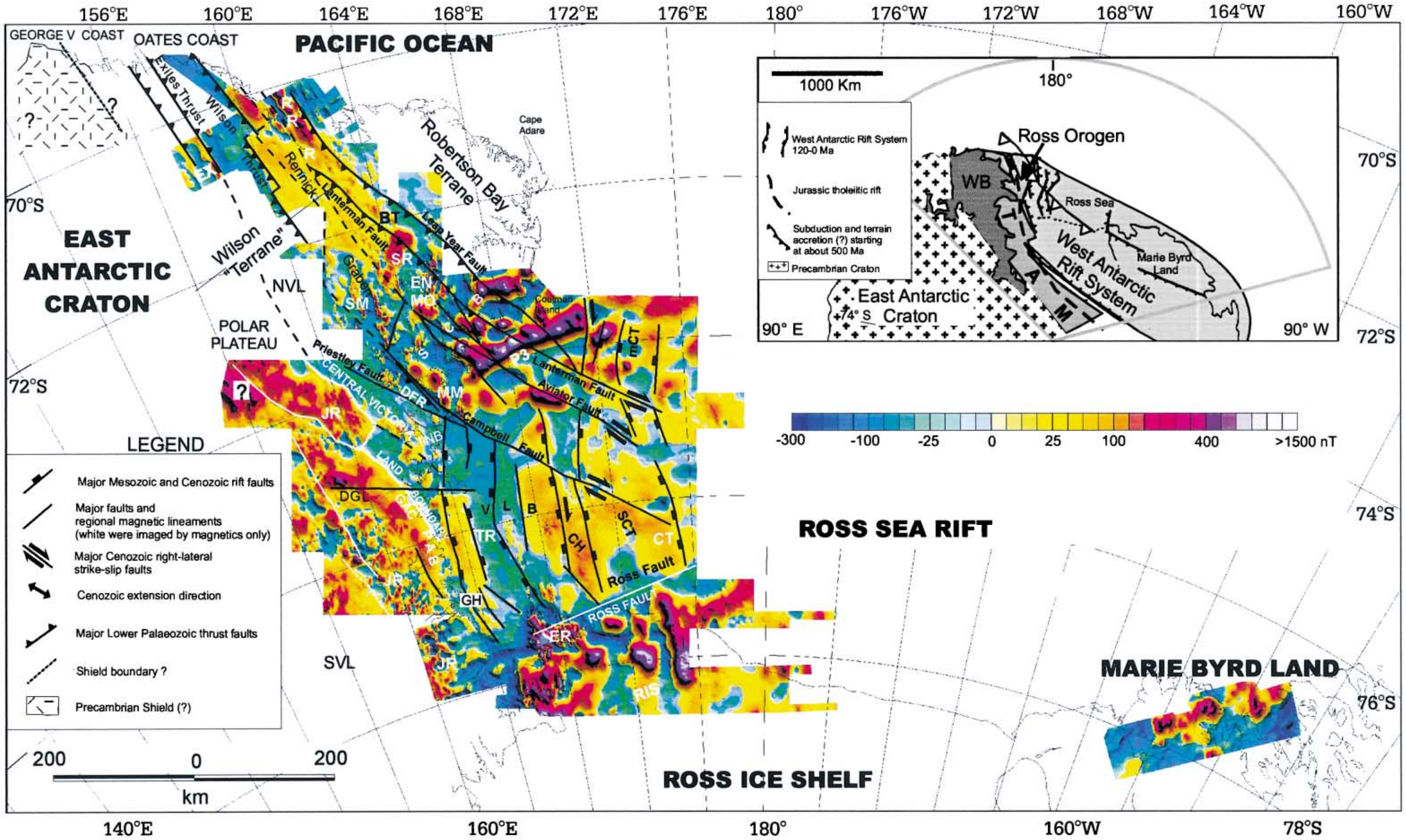


Fig. 5. Simplified tectonic sketch map superimposed on the newly compiled magnetic anomaly map. Magnetic features are labelled in white (e.g. the prominent Central Victoria Land Boundary), while black lettering refers to geologic features interpreted both from field data and seismic evidence. Crustal blocks along the TAM rift shoulder include: DFR (Deep Freeze Range); PAB (Prince Albert Mountains); SCB (Southern Cross Block); and TNB (Terra Nova Bay region). Interpreted magnetic anomalies include: BT (Bowers Terrane); CH (Central High); DGL (David Glacier Lineament); EN (Evans Névé); ER (Mount Erebus); EX (Exiles Thrust anomalies); GAC (GITARA Anomaly Complex); GH (Granite Harbour); JR (Jurassic tholeiites in the Rennick Graben); mCT (mid Central Trough); MO (Mount Overlord); MM (Mount Melbourne); NVL (Northern Victoria Land); P3 (Polar 3 Anomaly [Cenozoic Meander Intrusive Complex]); R (Rennick Glacier anomalies); RIS (Ross Ice Shelf [McMurdo Volcanic Group]); SCB (Southern Cross Block anomalies); SCT (Southern Central Trough); SR (Salamander Range [Pre-rift basement anomalies]) SVL (Southern Victoria Land); and TR (Terror Rift). The inset provides an overview of the regional geological features in the INTRAMAP region (grey shaded) that includes the subglacial Wilkes Basin (WB) along the "backside" of the Transantarctic Mountains (TAM).

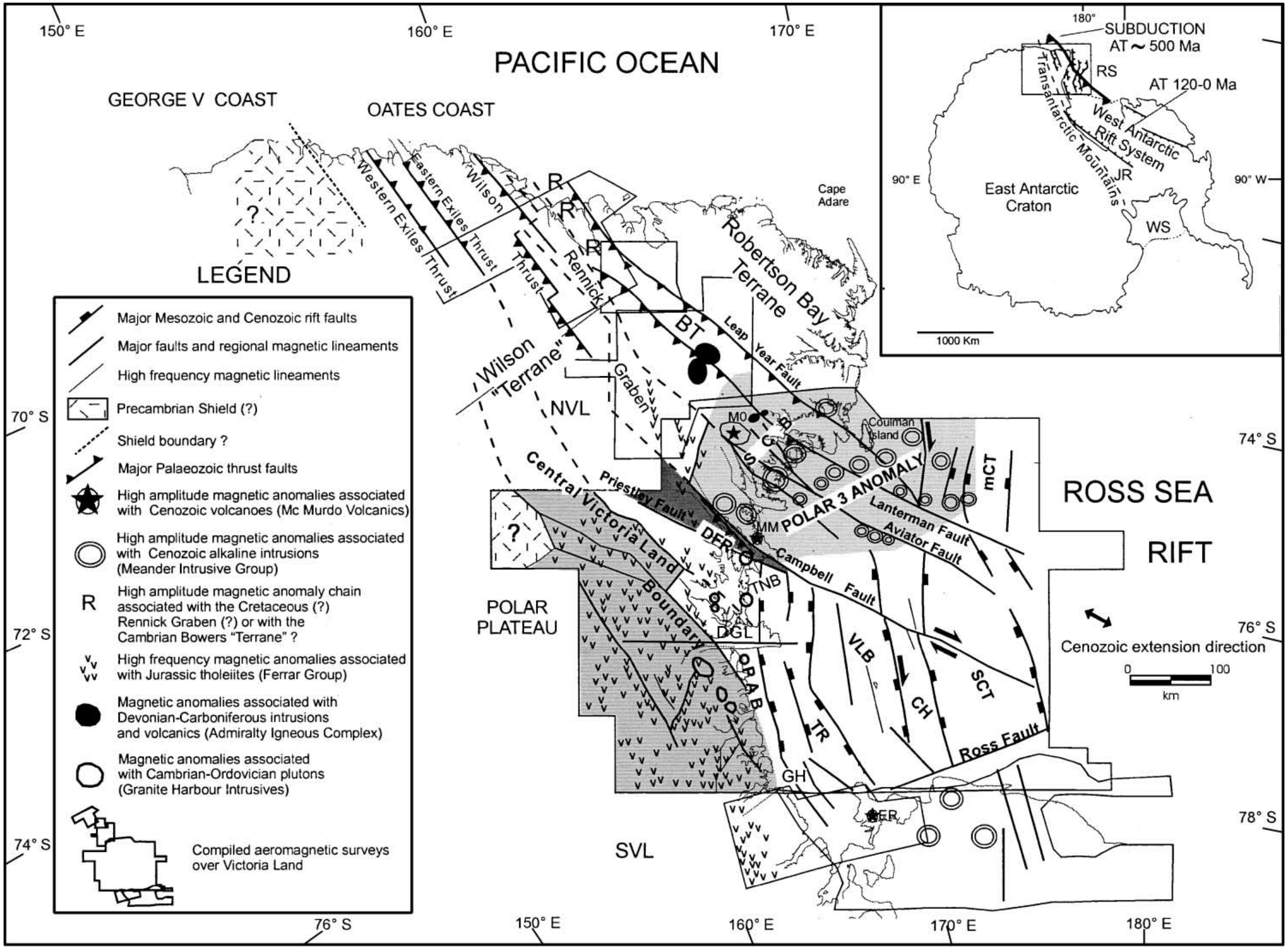


Fig. 6. Regional interpretation of magnetic features. The TAM rift shoulder appears to be made up of discrete crustal blocks that developed along faults inherited from the Ross Orogen. Cenozoic alkaline intrusions and volcanics may have been emplaced preferentially in the Southern Cross Mountains region, while the Jurassic tholeiites seem particularly widespread to the west of the Central Victoria Land Boundary. Also highlighted are the magnetic anomalies over the Granite Harbour Intrusives of the Wilson Terrane, as well as possible anomalies over the Bowers Terrane. See Fig. 5 for a list of the abbreviated features.

Furthermore, the remarkable segmentation of the Jurassic magnetic pattern across the Central Victoria Land Boundary (CVLB) was maintained in this new compilation, which was observed in a previous compilation effort (Chiappini et al., 1999b) where different data reduction and merging strategies were used. This segmentation may reflect preferential emplacement of the flood basalts in the inferred Jurassic rift to the west of the CVLB, or substantial post-Jurassic differential uplift of the TAM blocks, or some combination of the two mechanisms (Ferraccioli and Bozzo, 1999).

4.3. Transantarctic Mountains–Ross Sea component of the West Antarctic Rift System

The West Antarctic Rift is one of the largest continental rift systems in the world. However, its geologic history over the past 120 Ma is relatively poorly known (Davey and Brancolini, 1995). Plate tectonic reconstructions and structural data suggest limited Cenozoic extension, thus implying major regional extension in the Cretaceous (Lawver and Gahagan, 1994; Wilson, 1995) when seismically inferred major rift basins in the Ross Sea may have first formed (Davey and Brancolini, 1995). Onshore, paleomagnetic and structural data suggest Cretaceous tectonic activity along the Rennick Graben that links the Pacific Ocean and the Ross Sea (Roland and Tessensohn, 1987; Tessensohn and The Ross Sea Region, 1994).

Post-Eocene tectonic activity may be linked to reactivation of Ross-age Paleozoic faults in a right-lateral strike-slip regime (Salvini et al., 1997). Offshore in the Ross Sea, many rift faults identified from seismic data are evident in the magnetic anomaly compilation. The most prominent of these features involves the linear magnetic minima over the axial Terror Rift (TR in Figs. 5 and 6) of the Victoria Land Basin. The 40-km-wide by over 300-km-long Terror Rift appears to be truncated by the NW–SE Campbell Fault to the north and by the Ross Fault to the south (Behrendt et al., 1996). Other fault-bounded crustal blocks are characterized by broader and less well-defined magnetic maxima such as over the Central High and Southern Central Trough (CH and SCT in Figs. 5 and 6).

The magnetic anomaly compilation also provides insight on the distribution of the Cenozoic to Quaternary igneous rocks that reflect the extensional-to-transtensional tectonic history (Wilson, 1995) of the TAM–Ross Sea rift area. Alkali basalts of the McMurdo Volcanic Group suggest volcanism commenced between 25 and 18 Ma (LeMasurier and Thompson, 1990) along N–S trends of the Ross Sea rift margin. Prominent circular magnetic anomalies of the Southern Cross Block (SCB in Figs. 5 and 6) mark older (48–22 Ma) alkaline intrusives (Tonarini et al., 1997) that were emplaced possibly during the strike-slip kinematic regime.

5. Conclusions

We presented an important component of the ongoing magnetic anomaly compilation over the Antarctic continent. Most of the aeromagnetic data available for the TAM–Ross Sea sector was obtained from relatively high-resolution surveys with flight line spacing less than 5 km. Starting from the 1970s, the aeromagnetic data sets were collected by various Antarctic campaigns within national and international frameworks by the Italian, German, and US Antarctic programs. Airborne platforms, instrumentation, acquisition and navigation systems, and data processing procedures varied considerably. The compilation of these disparate data sets required the digitizing of old paper records and reprocessing the data by statistical levelling, microlevelling in the frequency domain, and re-adjusting for a common reference field based on the DGRF90 model. The reprocessing improved the signal-to-noise ratios of individual data sets and the coherency between adjacent surveys. The reprocessed grids were then sutured by a multi-frequency procedure to produce the final compilation.

The merged aeromagnetic anomaly map that we produced under the INTRAMAP banner provides new perspectives on regional scale magnetic patterns, which were difficult to perceive in the individual data sets. For example, magnetic trends are enhanced, which reveal some major basement structures that segment the TAM–Ross Sea rift region. Furthermore, the compilation featured the newly recognized linear, approximately 100-km wide and 600-km long positive anomaly over Southern Victoria Land that may reflect the effects of a Jurassic rift.

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