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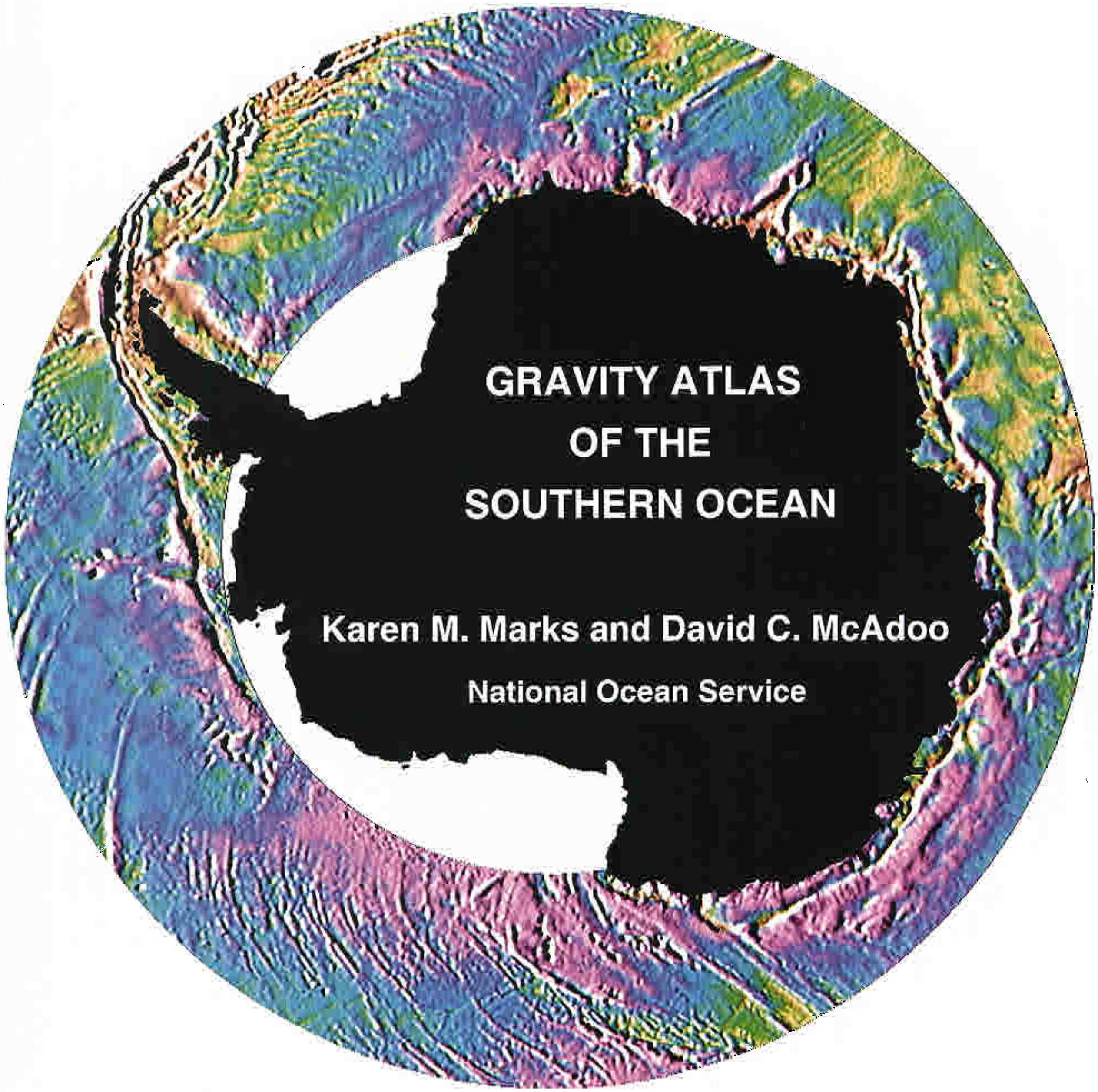

GRAVITY ATLAS OF THE SOUTHERN OCEAN

Karen M. Marks and David C. McAdoo

National Ocean Service

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

National Geophysical Data Center
World Data Center-A for Marine Geology and Geophysics
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Gravity Atlas of the Southern Ocean

Karen M. Marks and David C. McAdoo

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Office of Ocean and Earth Sciences
National Ocean Service, NOAA
Rockville, MD 20852

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U.S. DEPARTMENT OF COMMERCE
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National Oceanic and Atmospheric Administration
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Preface

Before the end of this century, satellite altimeter observations should cover the entire surface of the world's oceans, aside from those regions that are masked by permanent or persistent sea ice. Our first opportunity to evaluate these high-density data came in 1990, when the United States Navy declassified all of the Geodetic Mission (GM) data acquired by its Geosat satellite south of 60° S.[1] Our results, as detailed in this atlas and companion publications, surprised us. We knew that the Southern Ocean was among the most poorly charted regions of the entire ocean, and we expected that the high-density Geosat data would yield a considerably improved marine gravity field. What we did not know was that these altimeter data would yield a marine gravity field of such excellent precision and resolution that it could not be substantially improved by adding state-of-the-art shipboard gravity observations.

We present high-resolution marine gravity fields in this atlas. However, because short-wavelength gravity anomalies (10 km to 200 km) are highly correlated with bathymetry, these fields yield much new information about the topography of the seafloor. So, later this decade, when altimetric coverage of the world's oceans is complete, we will be able to chart the entire seafloor to a scale as fine as 10 km. Marine geophysics will have come along way since that time forty years ago, before the seminal work of Heezen and Tharp, when the vast majority of the seafloor was uncharted.

Karen M. Marks
David C. McAdoo

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[1] As this goes to press, we have learned that the United States Navy has declassified all GM data acquired south of 30°S; we gratefully acknowledge the Navy for their data and cooperation.

Foreword

The Southern Ocean has had fewer surface ship surveys than any of the other ocean basins; as a result very little information on its morphology and tectonics is available. With declassification of all Geodetic Mission radar altimeter data acquired by the Geosat satellite south of 60° S, our knowledge and understanding of the seafloor and tectonic fabric of this region has greatly increased. This report provides bathymetry plots, Geosat ground track coverage, ascending and descending deflection of the vertical images, as well as the most comprehensive gravity anomaly data available to date. This atlas serves as a companion to Report MGG-6, Gravity Field over the Southern Ocean from Geosat, and is intended as an initial source document for more detailed studies in the Southern Ocean.

The National Geophysical Data Center is pleased to make this report available as a reference volume to the marine science community and public. It constitutes the seventh in a series of scientific data reports published by the National Geophysical Data Center and World Data Center-A for Marine Geology and Geophysics.

Michael A. Chinnery

Director
National Geophysical Data Center

Michael S. Loughridge

Director
World Data Center-A for
Marine Geology and Geophysics

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Introduction

The Geosat spacecraft was developed jointly by the U.S. Navy and the Johns Hopkins Applied Physics Laboratory. It was launched on March 12, 1985, and performed two missions in succession: the primary Geodetic Mission (GM), and the subsequent Exact Repeat Mission (ERM). During the GM, classified altimeter data were collected along closely-spaced ground tracks (2-3 km at 60° S) from April 1, 1985 to September 30, 1986. Upon termination of the GM, the satellite was maneuvered into an orbit that repeated every 17 days (the ERM). During the ERM, which took place between November 12, 1986, and January 5, 1990, unclassified altimeter data were collected along widely-spaced ground tracks (~75 km at 60° S). Together, these Geosat missions mapped the surface topography of the world's oceans between 72° N and 72° S latitudes at an unprecedented accuracy and resolution.

In August 1990, the U. S. Navy declassified the Geodetic Mission data south of 60° S. These data were produced by NOAA/NOS and are available in the form of Geophysical Data Records (GDRs) from NOAA's National Oceanographic Data Center (Cheney et al., 1991). We have used these GM data along with those from the ERM (Cheney et al., 1986) to derive marine gravity fields over the Southern Ocean that encircles Antarctica. To date, no other region of the ocean has been so completely covered by such accurate and closely-spaced altimeter observations that are unclassified.

Ironically, this circum-Antarctic region is very poorly charted by ship or aircraft - as poorly as any part of the world's oceans. In roughly half of the 1° squares in this region, the seafloor is completely uncharted, that is, there are no available shipborne/airborne gravity observations or bathymetric soundings. In these uncharted areas, our gravity fields reveal many previously unknown short-wavelength (10-500 km) features in the seafloor such as seamounts, fracture zones, and mid-ocean ridge structures. The strong correlation between short-wavelength gravity anomalies and seafloor topography enables us to 'see' these bathymetric features in the gravity fields. Moreover, because fracture zones, passive continental margins, and other related features record the history of seafloor spreading, our gravity field images detail the regional tectonic history for the last 100 or more million years. Since the disintegration of Gondwana (the ancient supercontinent) some 140-160 million years ago, the Antarctic plate(s) has grown via seafloor accretion as South America, Africa, India, Australia, and New Zealand moved away. Many details of this accretion process can be seen in the gravity field images.

Directory

We have divided the circum-Antarctic study area into six regions, each spanning 60° of longitude. These regions (numbered I-VI) are shown in Figure 1. For each of these regions we have compiled plots of ETOPO5 seafloor bathymetry and Geosat ground track coverage (both ERM and GM), as well as color images of deflections of the vertical (both ascending and descending) and gravity anomalies. ETOPO5 is a gridded bathymetry data base that is available from the National Geophysical Data Center (Report 86-MGG-07).

In the color images, the gravity anomaly amplitudes range between -30 mGal (magenta) and +30 mGal (red) (±30 microradians for the deflections of the vertical), and are "illuminated" by a light source from the east. In many cases the gravity anomalies exhibit fine-scale features which have no apparent counterpart in the corresponding ETOPO5 bathymetry plots. This lack of correspondence is largely attributable to the sparse distribution of shipboard bathymetric observations used to construct the ETOPO5 data base.

Because the ascending and descending deflections of the vertical may also be viewed as horizontal gravity disturbances, the deflection images resemble those of the gravity anomalies. However, the deflections of the vertical have a long-wavelength background field removed, whereas the gravity anomalies have the background field restored.

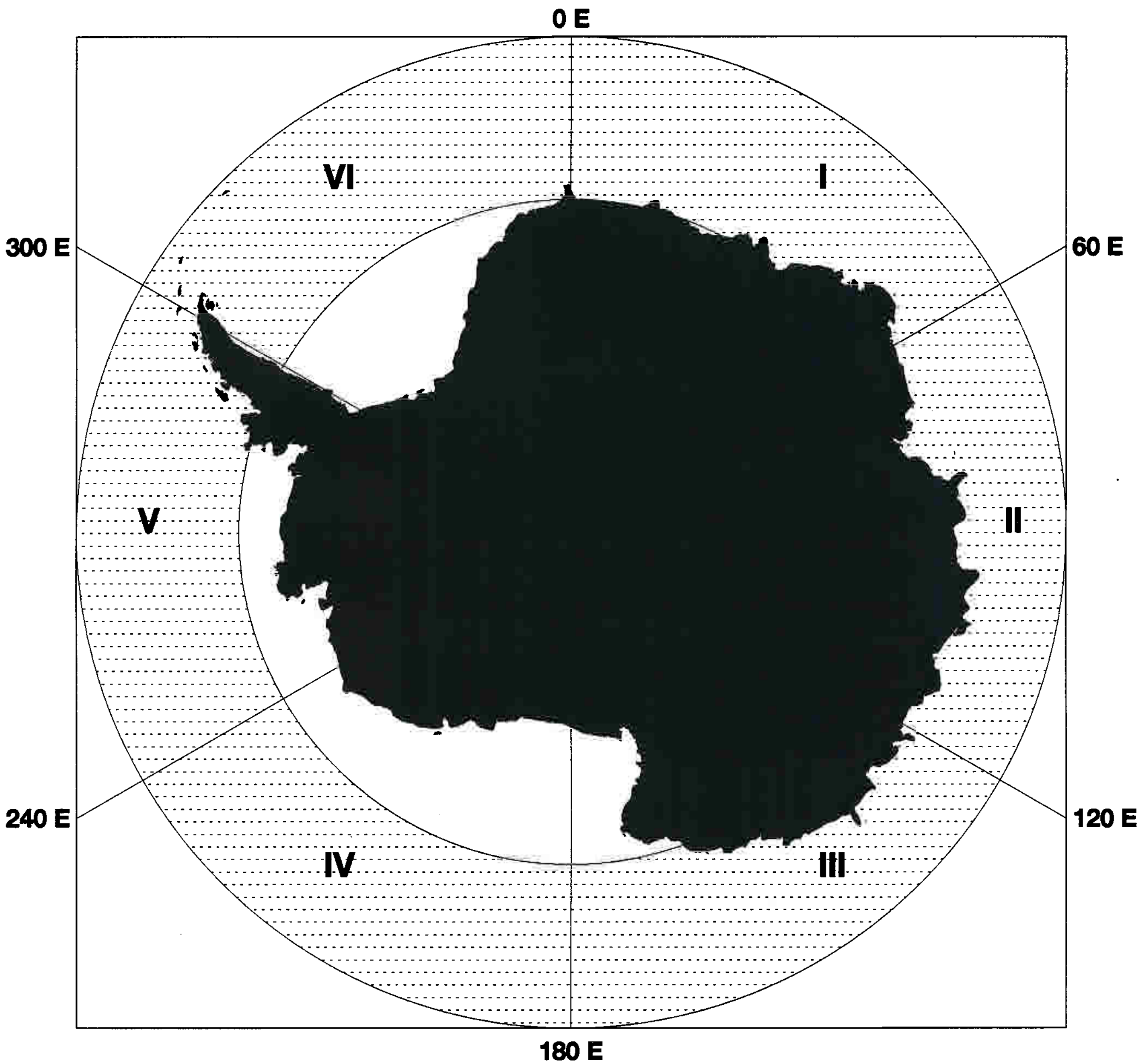

Figure 1. Directory

Computation of Gravity Fields

We began with profiles of sea surface height (from ERM years 1, 2, and 3, and GM GDRs), and ended with the gridded gravity anomalies that are shown in this atlas. The processing steps and computation method used to derive these gravity anomalies are only outlined here. For a more detailed discussion of the gravity derivations, see McAdoo and Marks (1992).

The first step was to convert the GDRs into two-per-second sea surface heights by fitting a sliding quadratic to the 10-per-second data. When the root-mean-square (RMS) deviations of the 10 Hz data exceeded 0.1 m, the 2 Hz heights were edited. We made all the appropriate corrections to the sea surface height data, including those for ocean and solid earth tides, as well as ionospheric and tropospheric travel time delays. The heights were also edited to remove outliers. Along-track deflections of the vertical were then computed by differentiating the filtered sea surface heights with respect to distance along the satellite pass. Furthermore, we filtered the data to pass only gravity anomalies in the 10-2000 km waveband. This was accomplished by subtracting a low-order background field, and high-cut filtering with a Gaussian smoothing function.

The next step was to interpolate the along-track deflections (in two separate operations: one on ascending and one on descending) onto a standard rectangular grid having a grid interval of 0.05° latitude and 0.10° longitude (or approximately 5 km by 5 km). Simple vector algebra was used to compute the east and north deflection components from the gridded ascending and descending deflections.

The last step was to forward Fourier transform the east and north deflection components into the frequency domain, and multiply them by the inverse Vening Meinesz filter. This filter converts the deflection components into gravity anomalies. Finally, the gravity anomalies were inverse Fourier transformed into the spatial domain, and the low-order field was restored. These gravity anomalies are available in digital and poster form from NOAA's National Geophysical Data Center (Marks and McAdoo, 1992).

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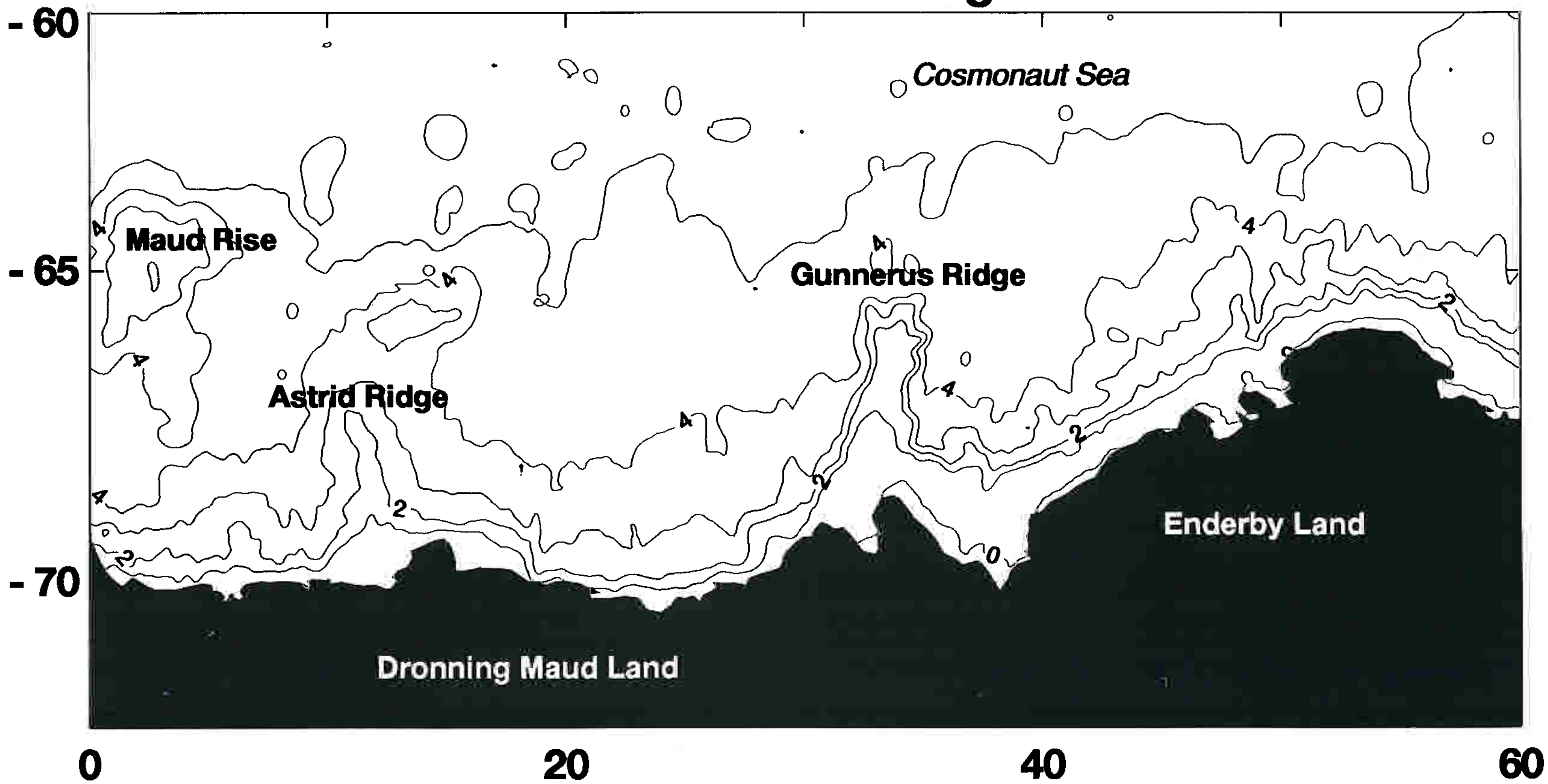
I: Gunnerus Ridge

This region spans 0° to 60° E, and covers the Lazarev, Riiser-Larsen, and Cosmonaut Seas, which make up the southernmost portions of the Atlantic and Indian Oceans. The Geodetic Mission ground track coverage is dense in this region, but terminates approximately 80 km seaward of Dronning Maud Land due to the sea ice cover which persisted through the austral summers of 1985 and 1986. The ERM tracks fill in this gap, thereby extending the satellite coverage to within approximately 25 km of Antarctica's coastline. Aside from this 25 km wide region bordering Antarctica, Geosat data provide virtually complete coverage of the ocean in region I. The small-scale anomalies viewed in the vertical deflections and gravity field are well constrained by the densely-spaced Geosat data.

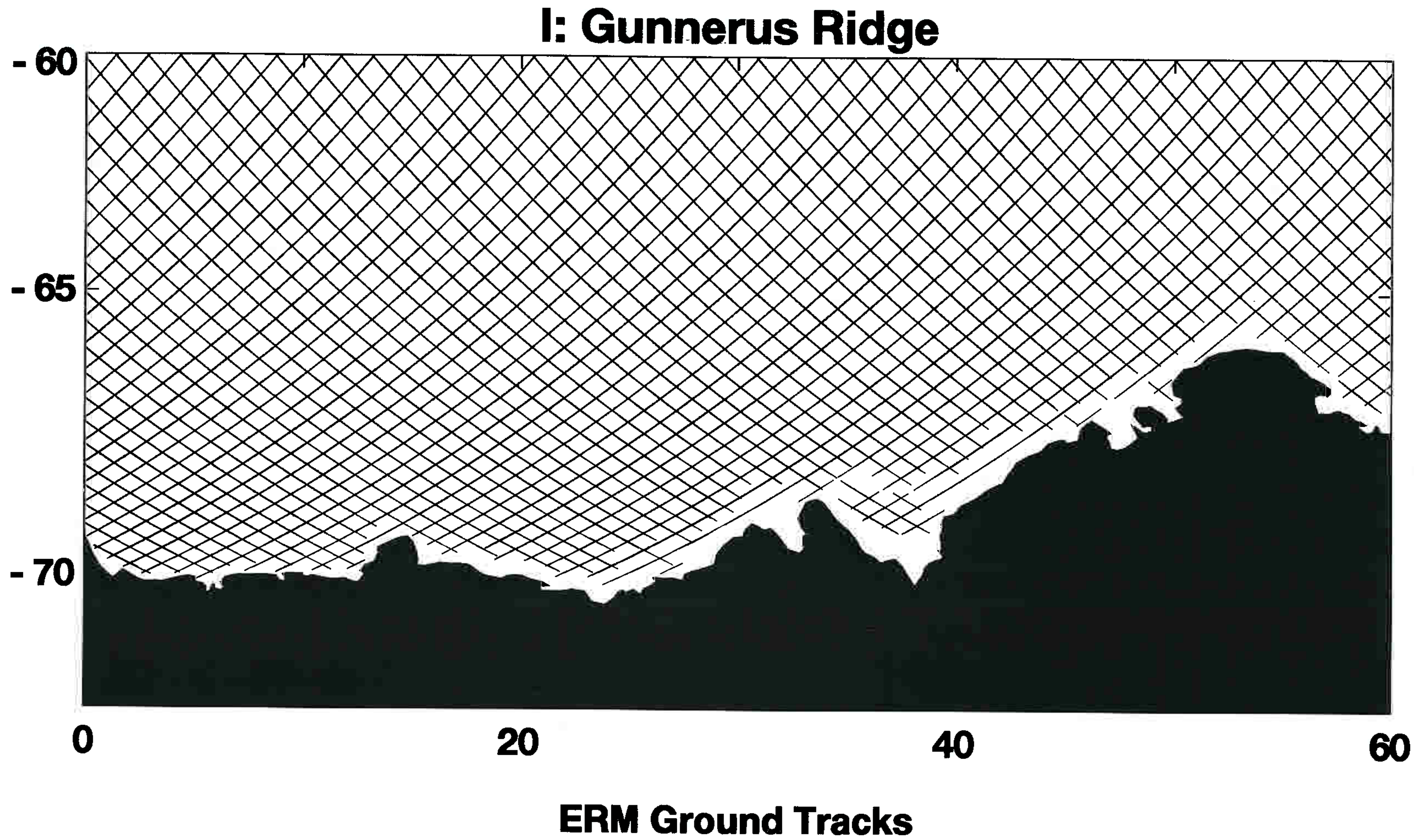
For example, the continental shelf seaward of Enderby Land, and the large submarine canyons located on it, are clearly seen in the deflections and gravity field. The Gunnerus ridge and the smaller Astrid ridge to the west (see bathymetry plot) are both associated with north-south trending gravity anomaly highs. The Maud rise is also overlain by a gravity anomaly high. Between 0° and 22° E, in the vicinity of the Maud rise, southwest- and southeast- trending fracture zones meet in an area of chaotically distributed gravity anomalies. An extinct triple junction appears to be the source of these anomalies. The Bouvet triple junction is located ~1500 km to the north, and it is possible that the extinct triple junction is the forerunner of the Bouvet. The most prominent of the southwest trending fracture zones (FZs) is the Astrid FZ which terminates near the northern tip of the Astrid ridge and which can be seen well in both the gravity anomaly and ascending deflection image. Other fracture zones are seen trending southwesterly towards the Gunnerus ridge and also towards Enderby Land. The trends of these fracture zones reflect the early (probably Cretaceous) direction of relative spreading between the Indian and Antarctic plates.

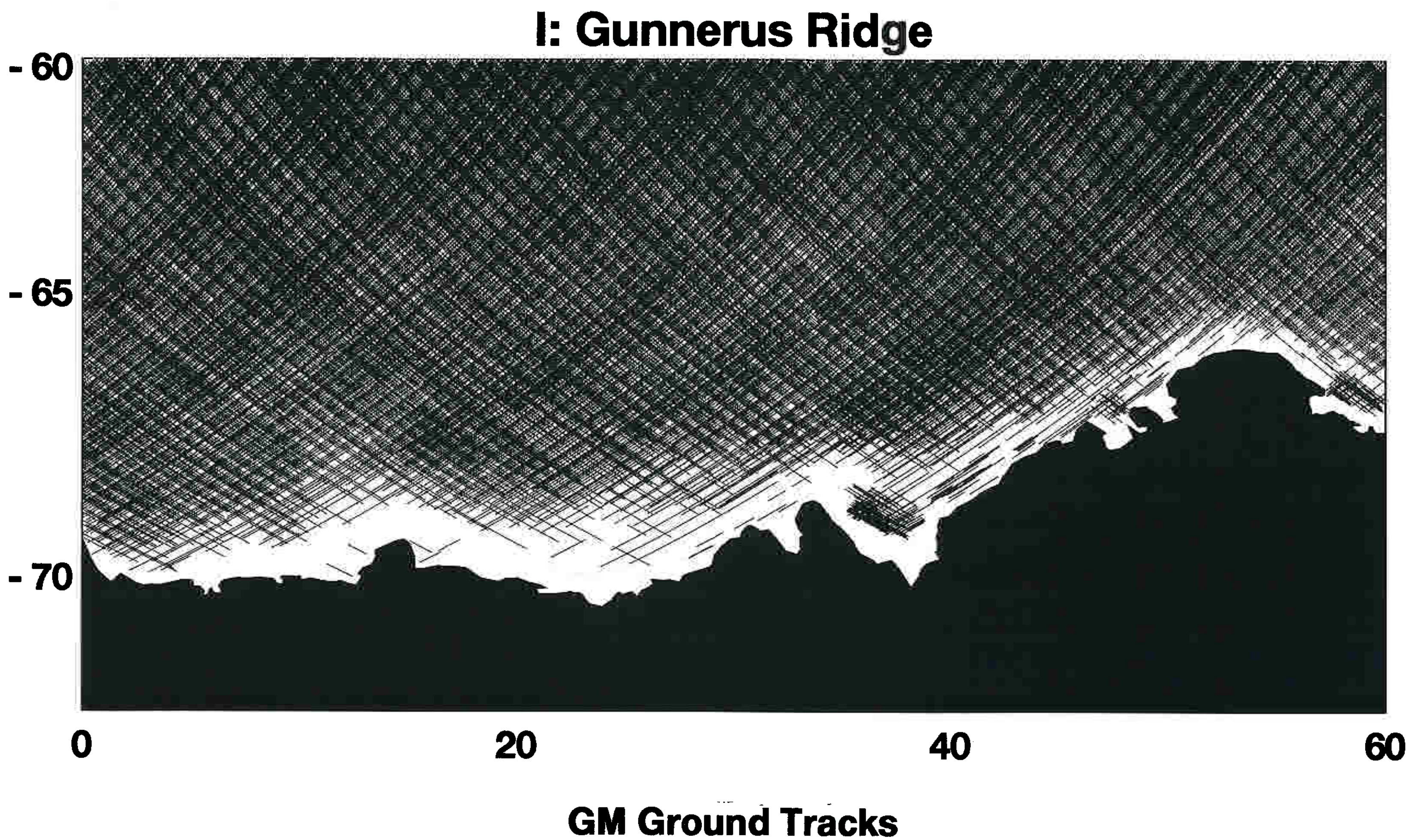
The tectonic features discussed above are all a consequence of the Mesozoic breakup between East and West Gondwana and the subsequent separation of Africa, Madagascar and India from Antarctica (Norton and Sclater, 1979). Prior to this breakup, Dronning Maud Land is believed to have adjoined Madagascar and the east coast of Africa, and Enderby Land to have abutted India.

I: Gunnerus Ridge



Bathymetry


I: Gunnerus Ridge
- 60
- 65
- 70
0
20
40
60
ERM Ground Tracks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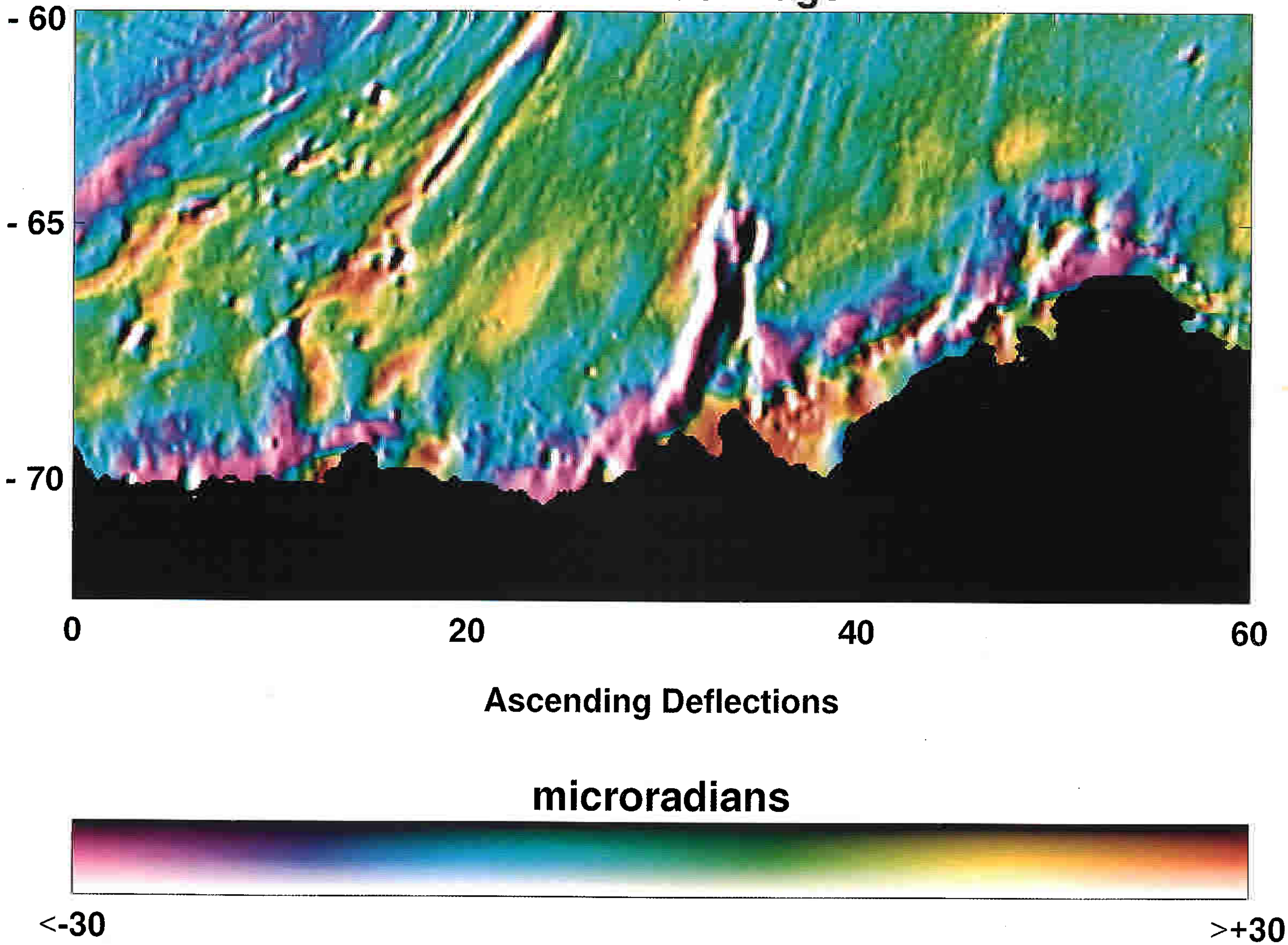
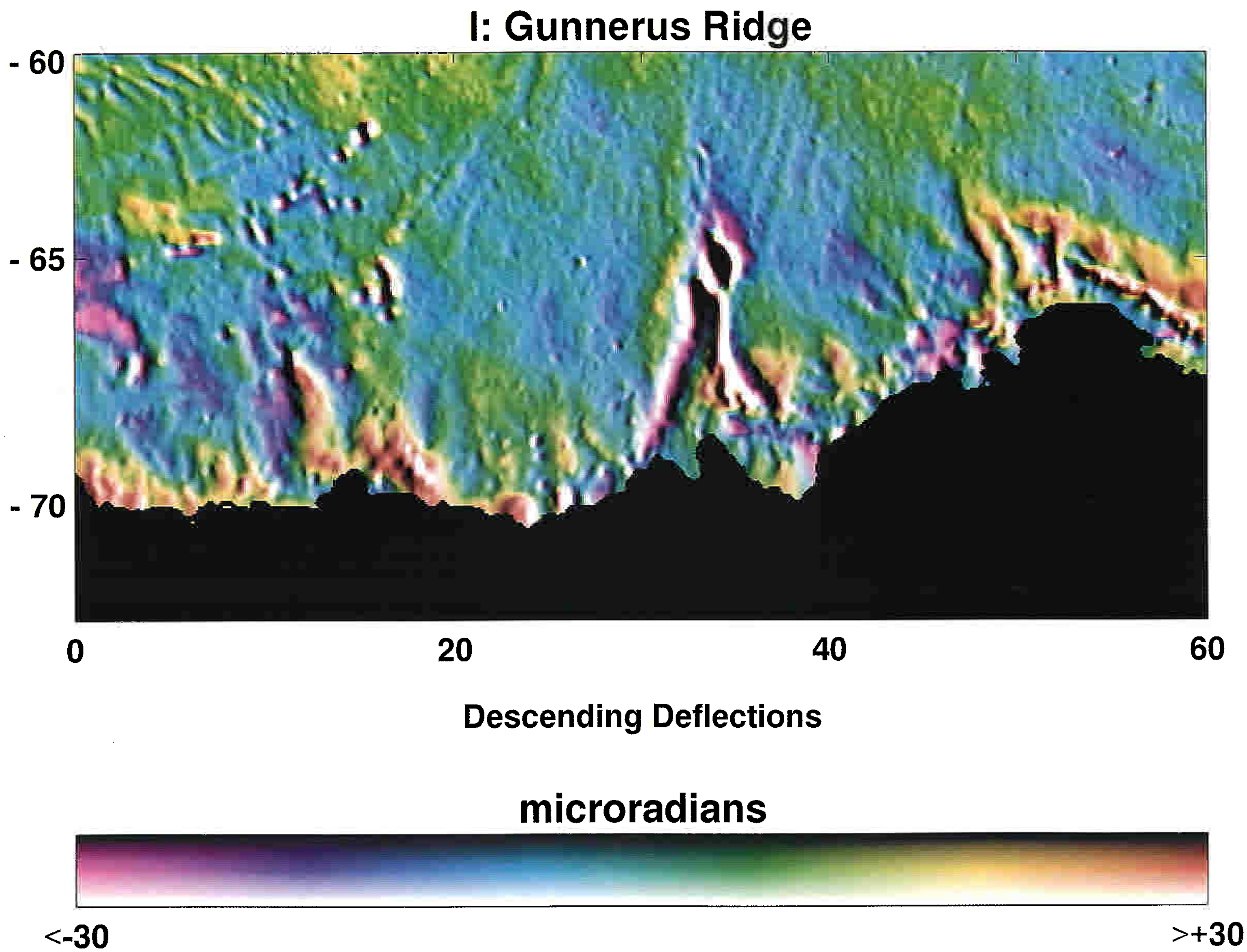
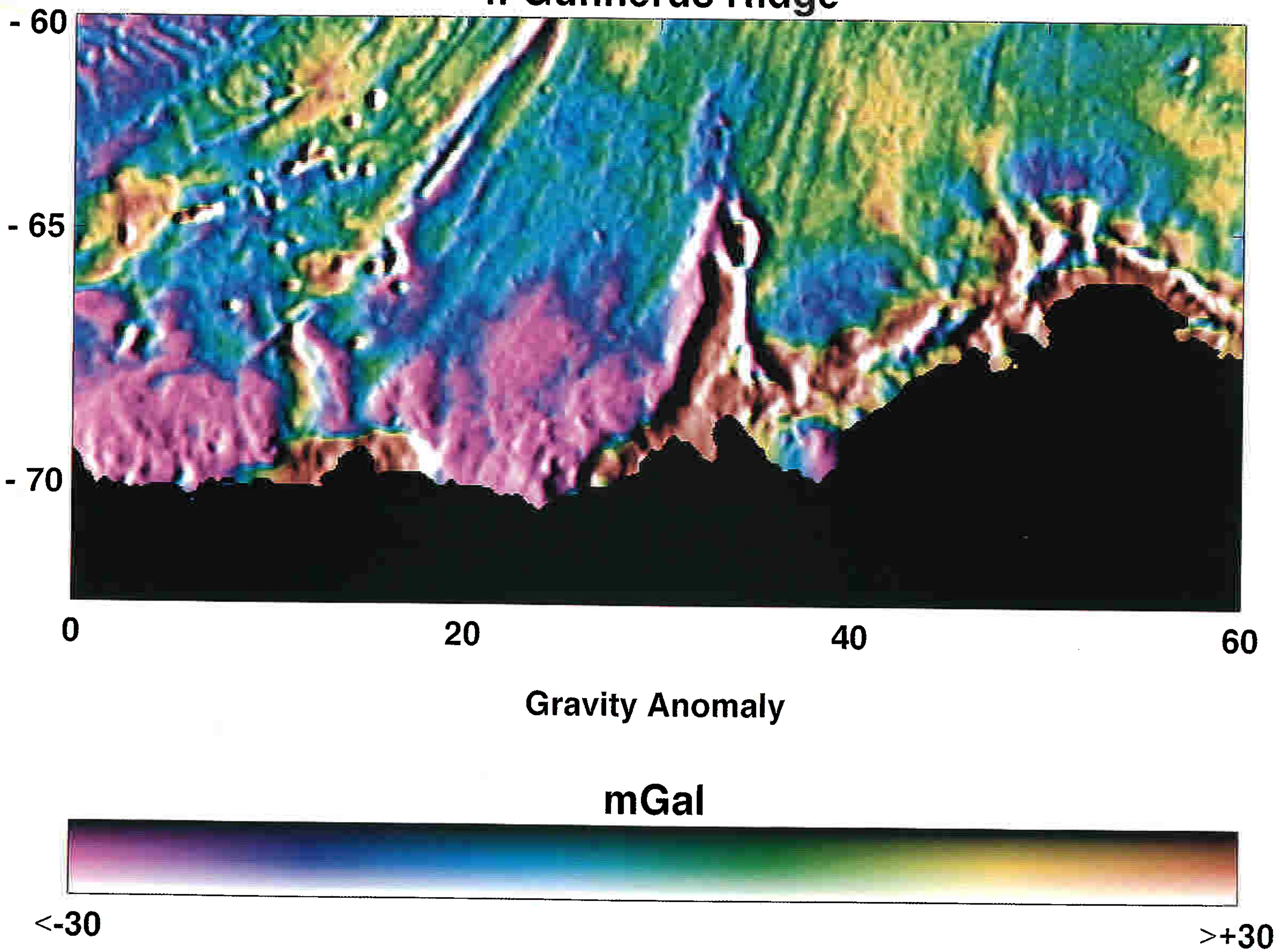
- 60
- 65
- 70
0
20
40
60
GM Ground Tracks

I: Gunnerus Ridge




I: Gunnerus Ridge
- 60
- 65
- 70
0
20
40
60
Descending Deflections
microradians
<-30
>+30

I: Gunnerus Ridge



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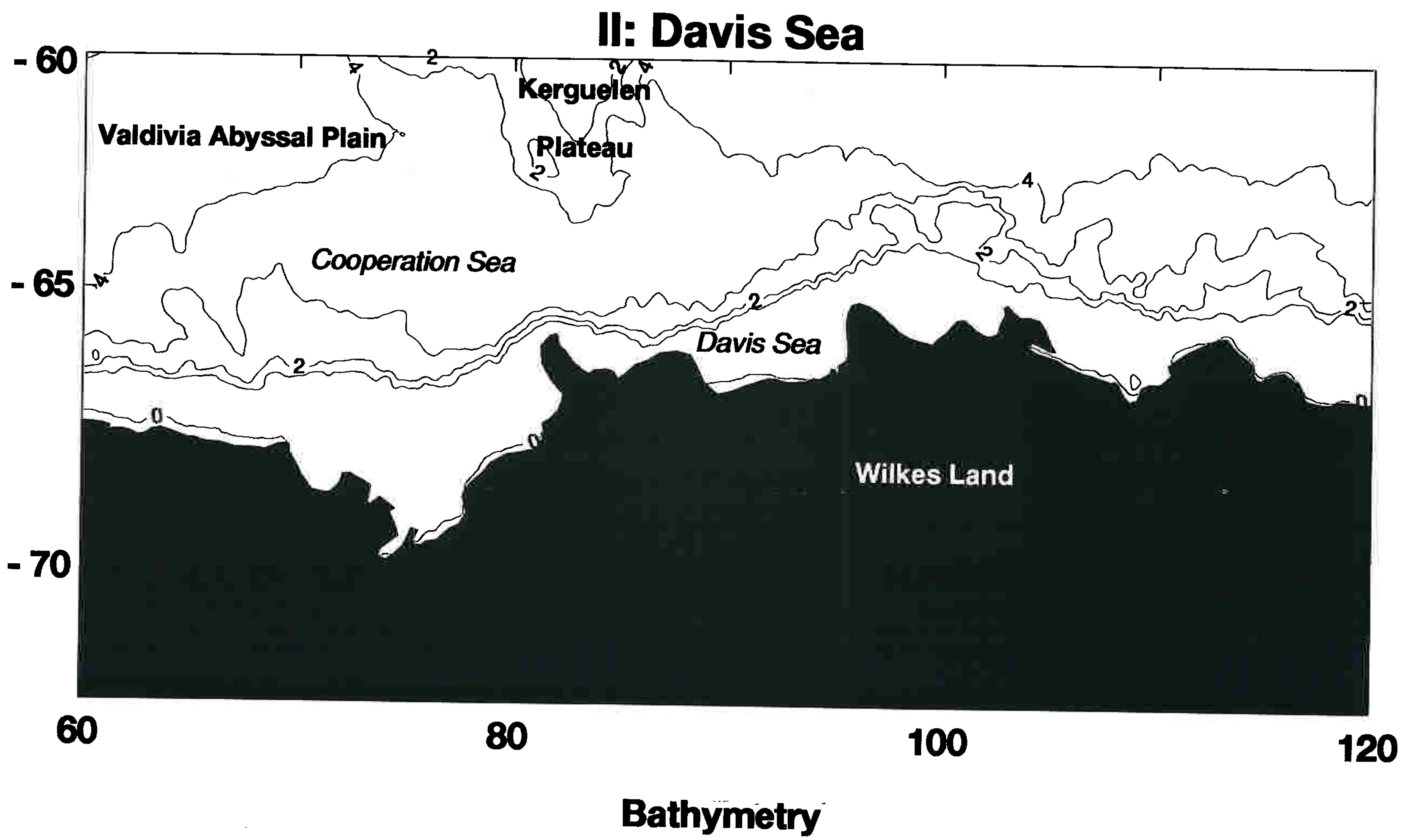
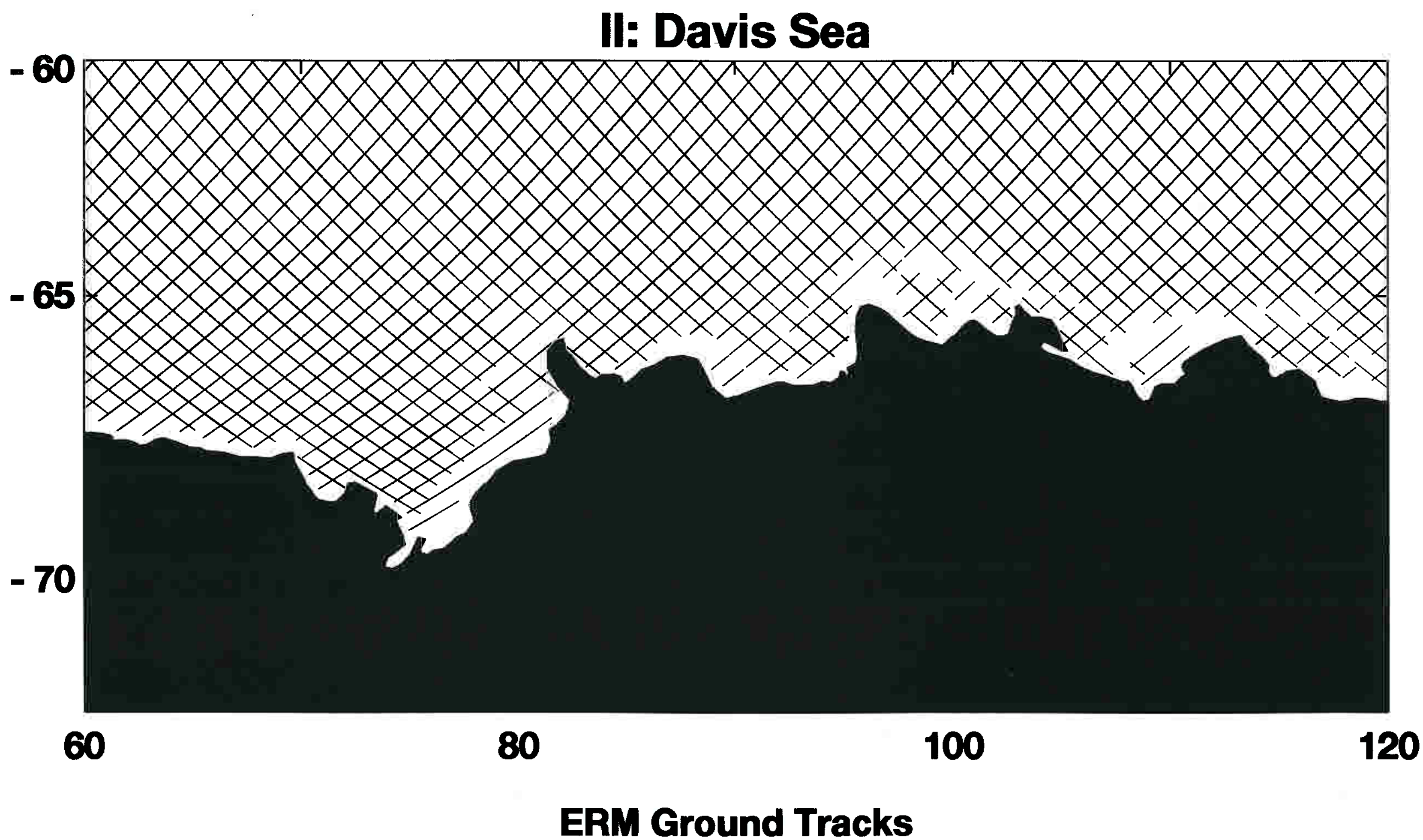
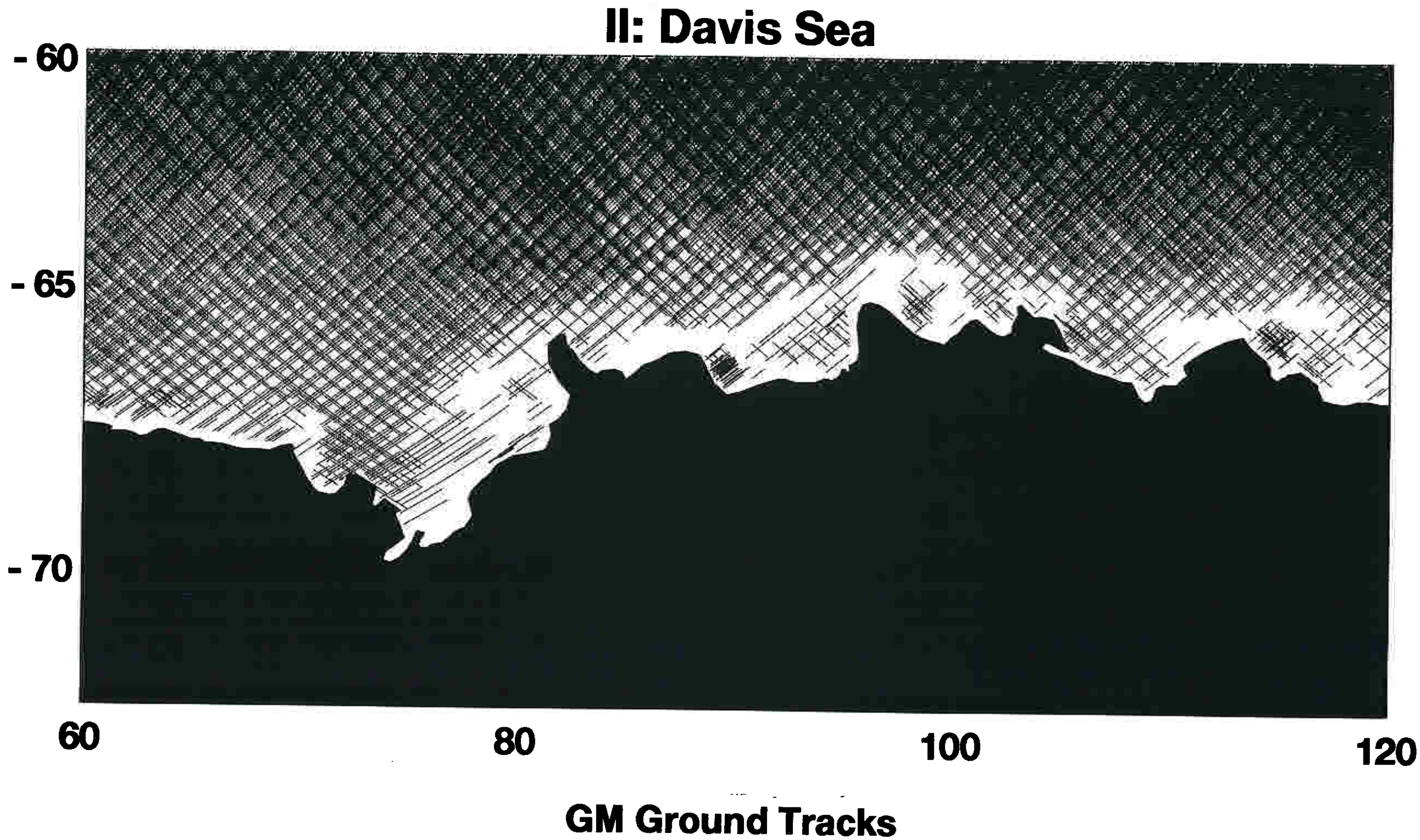
II: Davis Sea

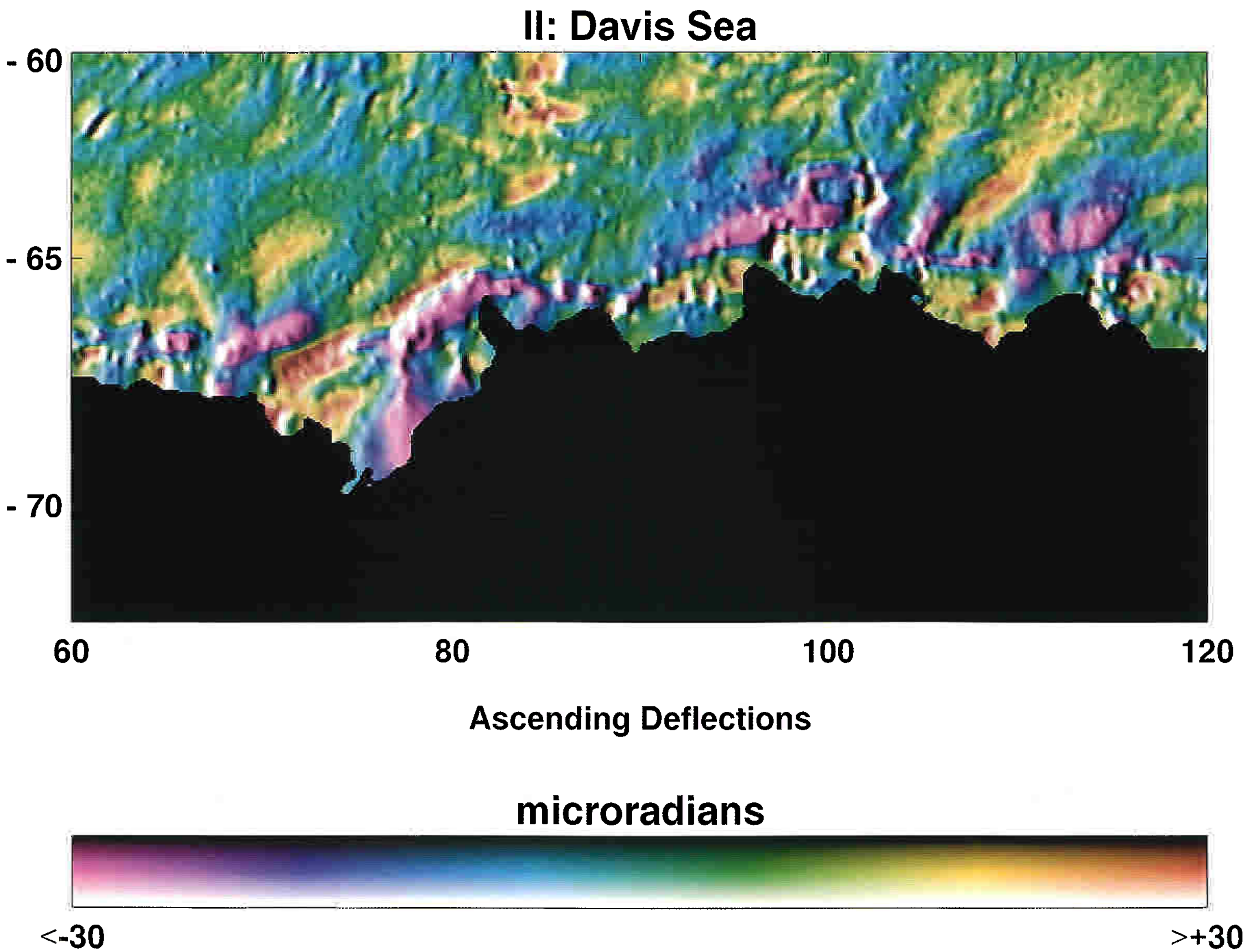
The Davis Sea region, which lies between 60° and 120° E longitude, encompasses both the Davis and Cooperation Seas. These seas lie in the southern reaches of the South Indian basin. As with the Gunnerus region to the west, the ERM ground track coverage near the Antarctic margin is more extensive than the GM coverage because of sea ice cover that was present in 1985 and 1986 while the GM data were collected. However, the areas to the north have dense satellite coverage. Although smaller-scale anomalies are resolved, most of the deflection and gravity anomalies in this region are unremarkable because there are few prominent tectonic features. For example, the Valdivia abyssal plain (see bathymetry plot) is associated with subdued gravity and deflection anomalies. The most salient feature is the Kerguelen plateau, whose southern end is expressed as a bathymetric and gravity high between 80° and 85° E. The Kerguelen-Heard ridge, and its conjugate, the Broken ridge, are believed to have been generated at the Southeast Indian ridge prior to 40 Ma, and were subsequently split apart by seafloor spreading (Recq and Charvis, 1986). The continental shelf (and submarine canyons) seaward of Antarctica are clearly seen in the deflection and gravity images, as is the western portion of a gravity low or "moat" seaward of the continental shelf. McAdoo and Marks (1991) have proposed that this gravity moat, which extends at least as far east as 170° E (into region III), is due to the mechanical response of the solid earth to ice sheets that were more extensive in the early Holocene. Apparently, the viscous relaxation of the earth that was initiated by the melting of the East Antarctic ice sheet is not yet complete.

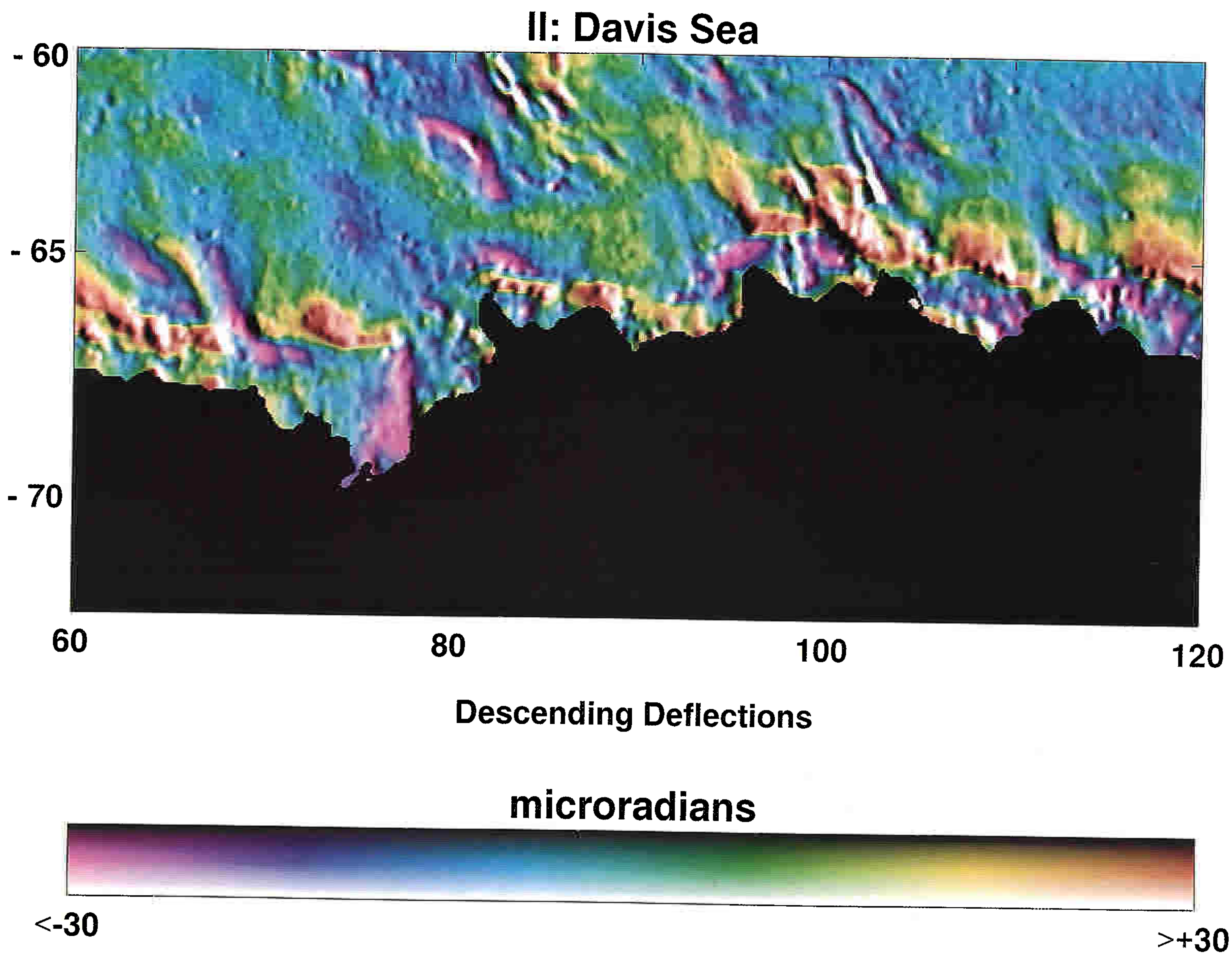


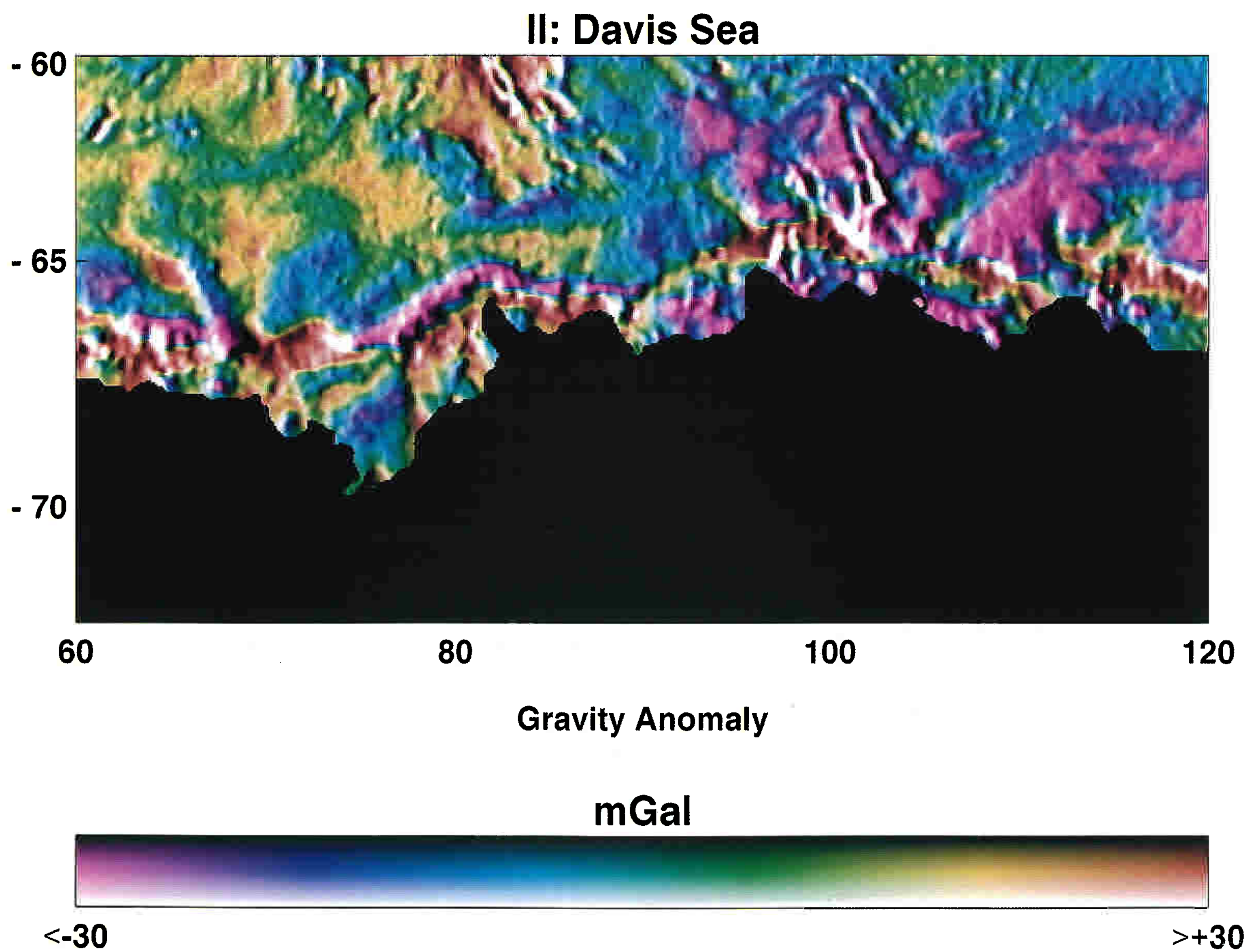
II: Davis Sea
- 60
- 65
- 70
60
80
100
120
Valdivia Abyssal Plain
Kerguelen
Plateau
Cooperation Sea
Davis Sea
Wilkes Land
4
2
0
Bathymetry


II: Davis Sea
- 60
- 65
- 70
60
80
100
120
ERM Ground Tracks


II: Davis Sea
- 60
- 65
- 70
60
80
100
120
GM Ground Tracks


II: Davis Sea
- 60
- 65
- 70
60
80
100
120
Ascending Deflections
microradians
<-30
>+30


II: Davis Sea
- 60
- 65
- 70
60
80
100
120
Descending Deflections
microradians
<-30
>+30


II: Davis Sea
- 60
- 65
- 70
60
80
100
120
Gravity Anomaly
mGal
<-30
>+30

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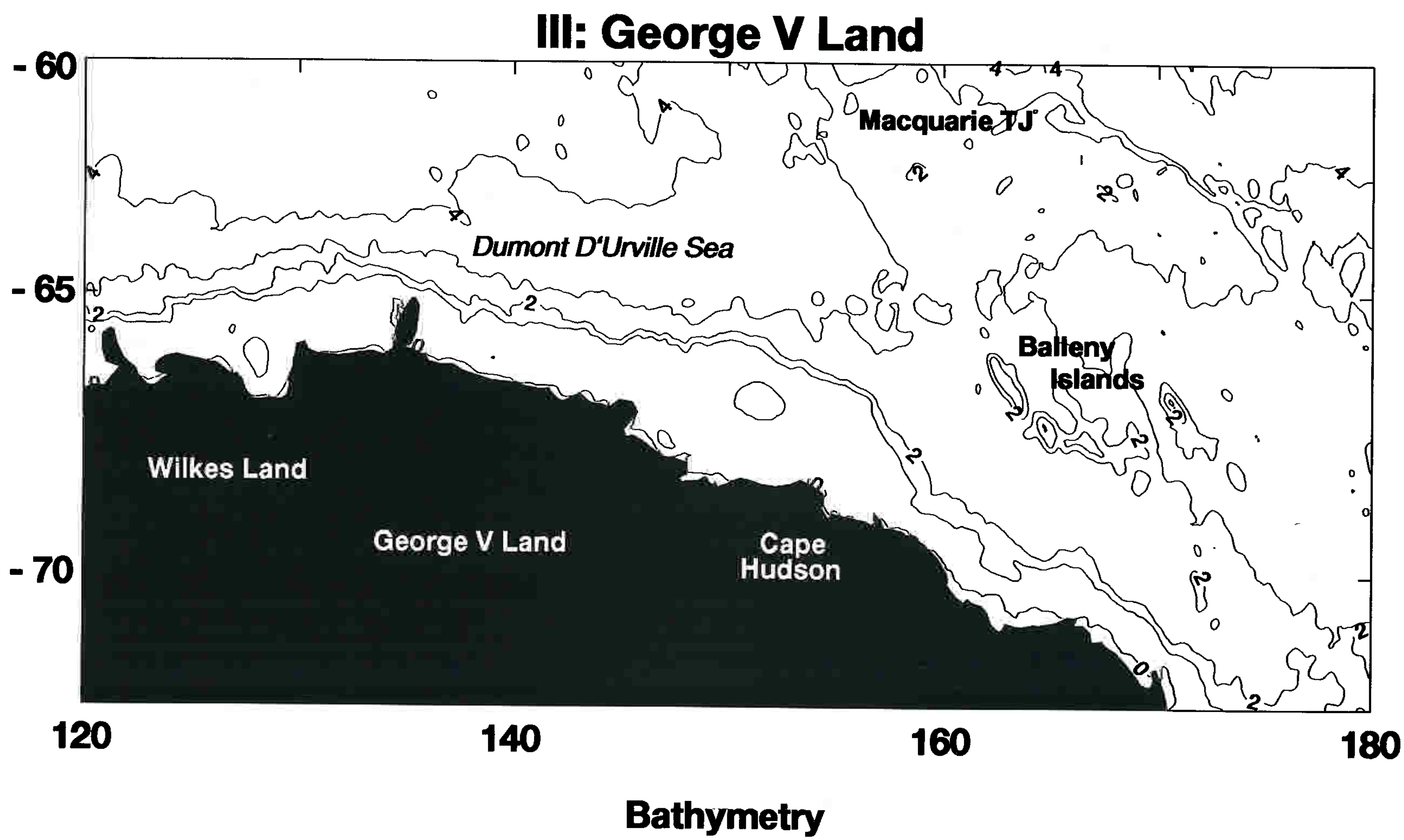
III: George V Land

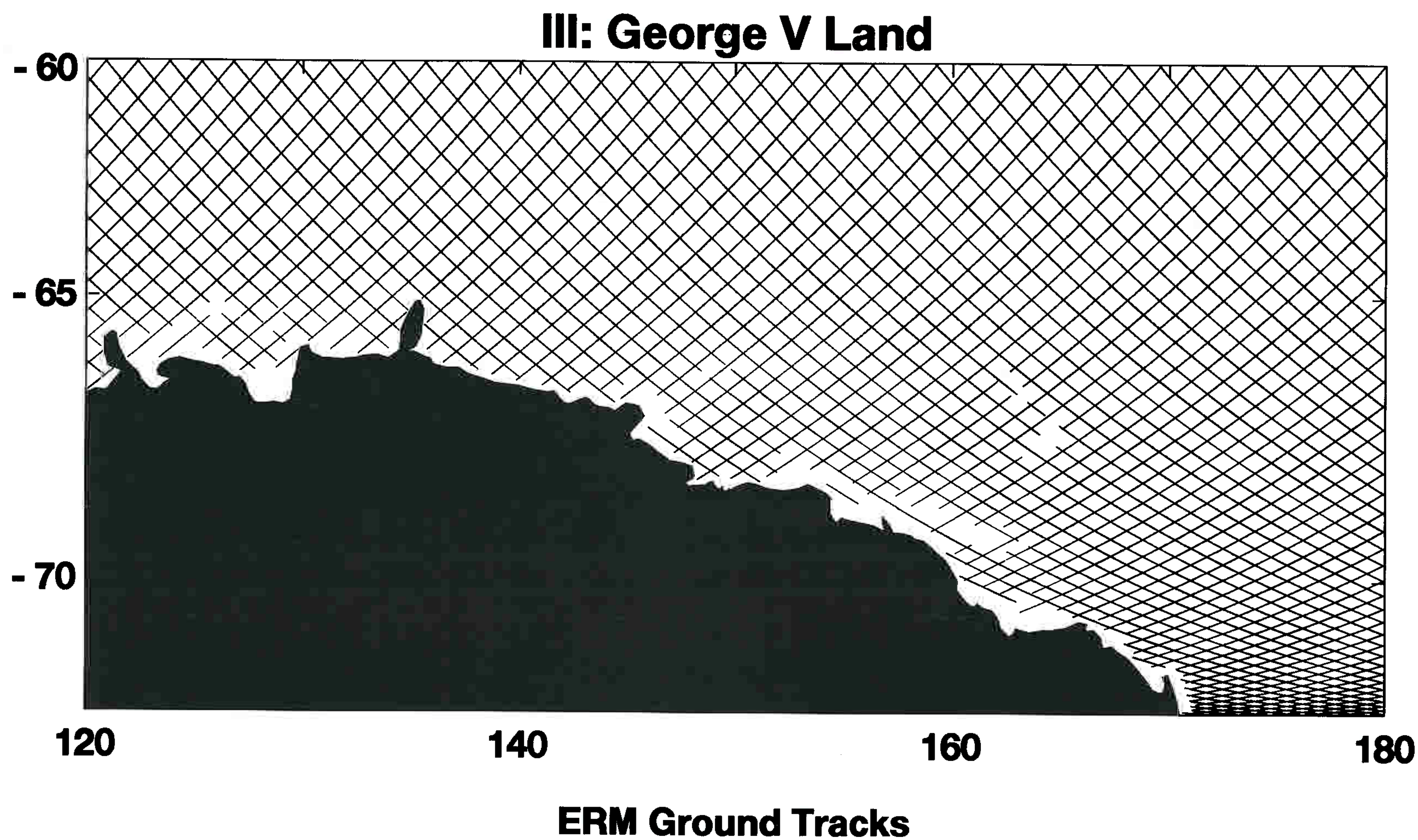
To the north of Wilkes Land and George V Land lies the South Indian basin, and the Dumont D'Urville Sea. The George V Land region, located between 120° and 180° E longitude, encompasses these features and also the southern part of the Southeast Indian Ocean. Extensive ERM and GM data were successfully acquired close to the Antarctic margin, except near Cape Hudson (see bathymetry and ground track plots). However, the remainder of the region is densely covered with altimeter observations.

Tectonic features of major importance are revealed in the color images of this region. In particular, portions of two active mid-ocean spreading ridges are evident. At approximately 155° E and 63° S, the Southeast Indian ridge (SEIR) is intersected and offset by the southeasterly-trending Balleny fracture zone. The axis of this easternmost segment of the SEIR appears as a lineated, southwest-northeast trending high (a yellow color) in the gravity field. Slightly to the east, at the Macquarie triple junction (approximately 160° E, 62° S), the SEIR terminates and the Pacific-Antarctic ridge begins. East of the Macquarie triple junction, the Pacific-Antarctic ridge steps to the southeast in a series of small-offset ridge segments, which are associated with gravity anomaly highs. These spreading segments formed when a recent (<5 Ma) change in the pole of rotation created extension across a large, old, NW-SE trending fracture zone, causing it to become "leaky" (Marks et al., 1991). The split fracture zone shows up (in the descending vertical deflections) as a prominent NW-SE trending high north of the small-offset ridge/transform system, and as a NW-SE trending low to the south.

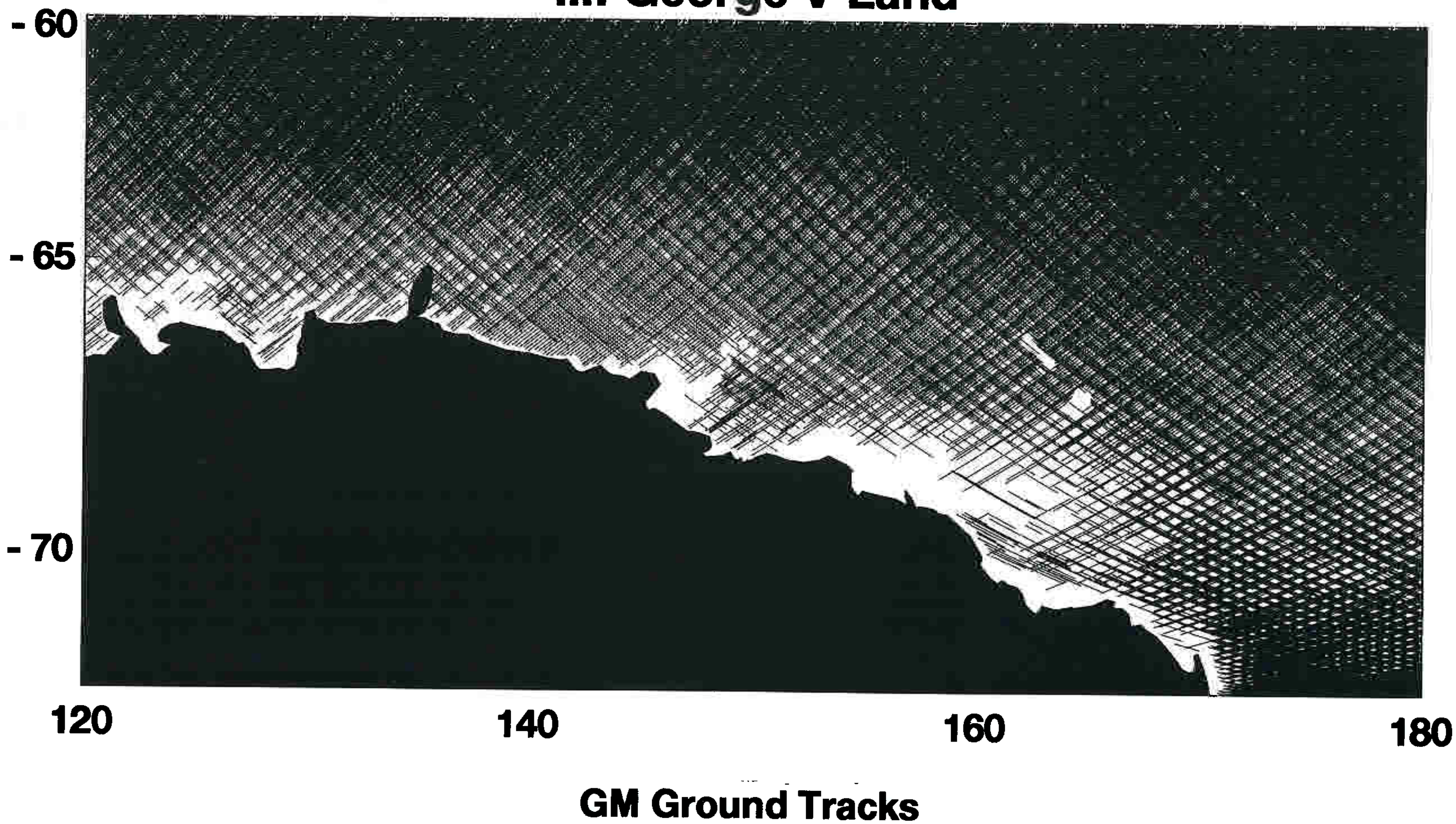
Other major fracture zones are evident in the deflection and gravity anomaly images. The Tasman and Balleny fracture zones which trend southeasterly between 150° and 155° E are prominent. Near the southern end of Balleny FZ lie the Balleny Islands, which are comprised of a southeasterly-trending seamount chain associated with local gravity anomaly highs. The Tasman and the Balleny FZs trace the separation of Australia from East Antarctica during the Cenozoic. Prior to this separation, Australia was attached to Antarctica along the Wilkes and George V Land margins.

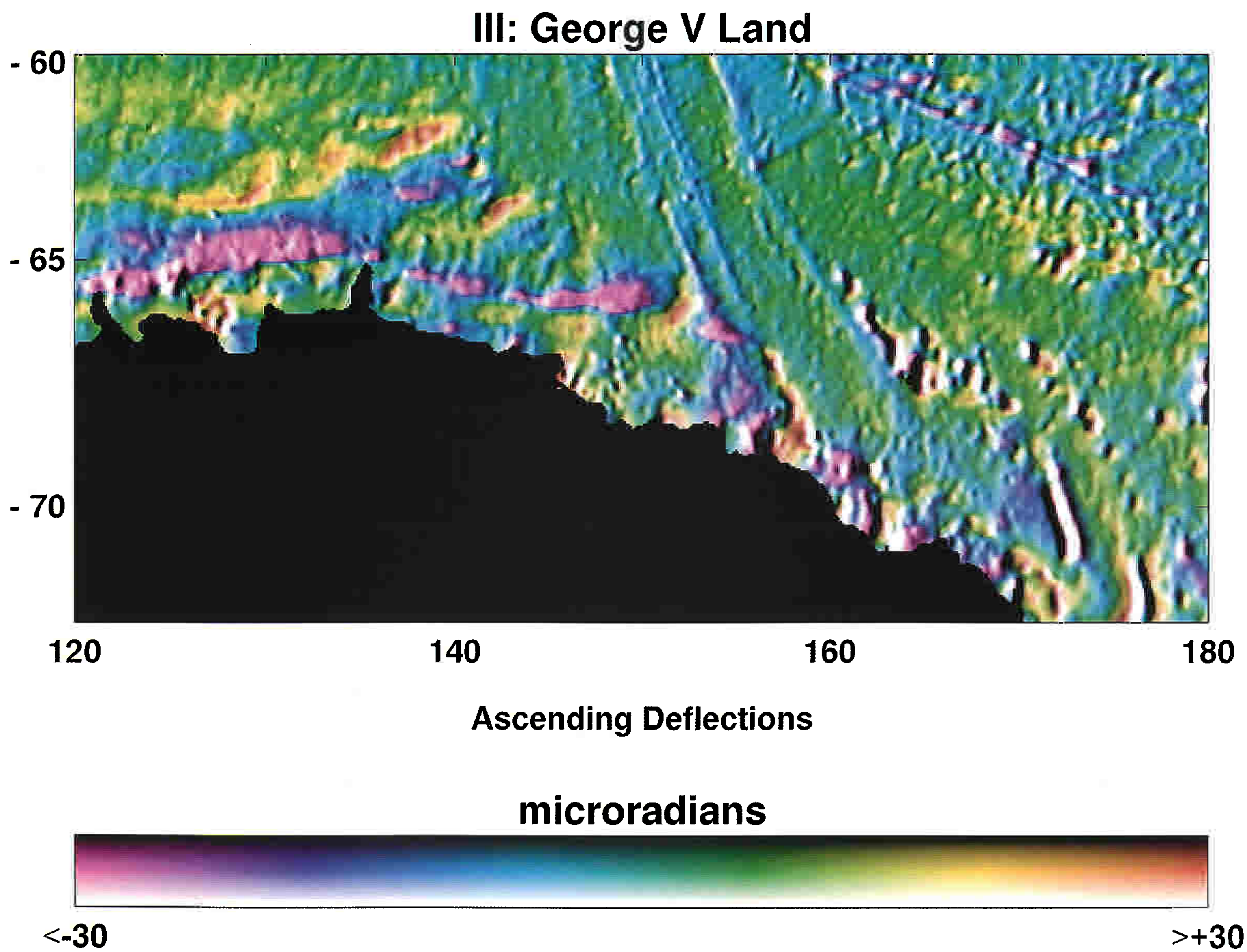
Also note that a gravity 'moat' lies seaward of the continental shelf offshore Wilkes Land and George V Land in the Dumont D'Urville Sea. This moat is the eastern continuation of the gravity low identified in Region II, and is attributed to the incomplete viscous response of the solid earth to a large, early Holocene, East Antarctic ice sheet.


III: George V Land
- 60
- 65
- 70
120
140
160
180
Dumont D'Urville Sea
Macquarie TJ
Balleny
Islands
Wilkes Land
George V Land
Cape
Hudson
Bathymetry

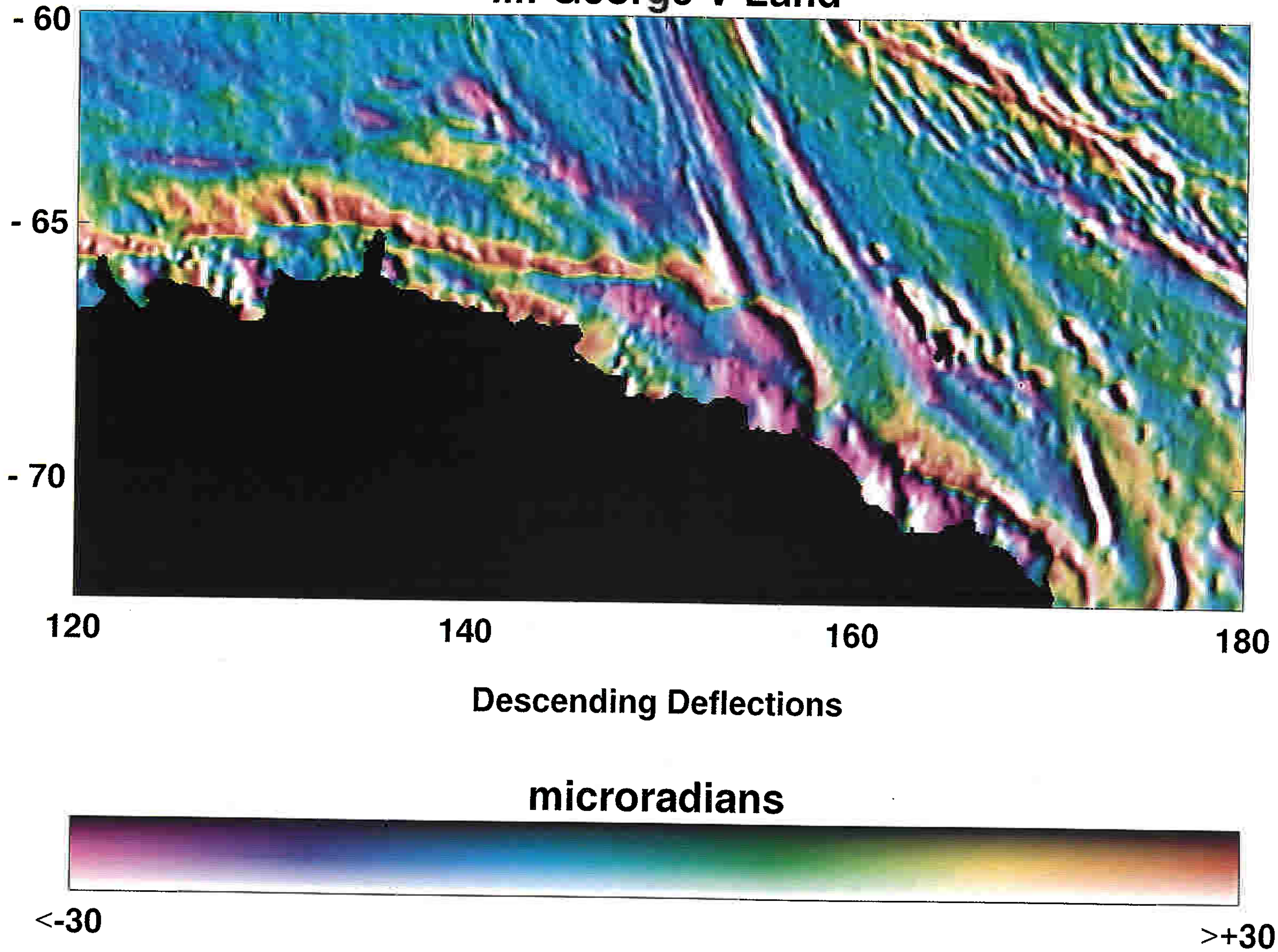

III: George V Land
- 60
- 65
- 70
120
140
160
180
ERM Ground Tracks

III: George V Land

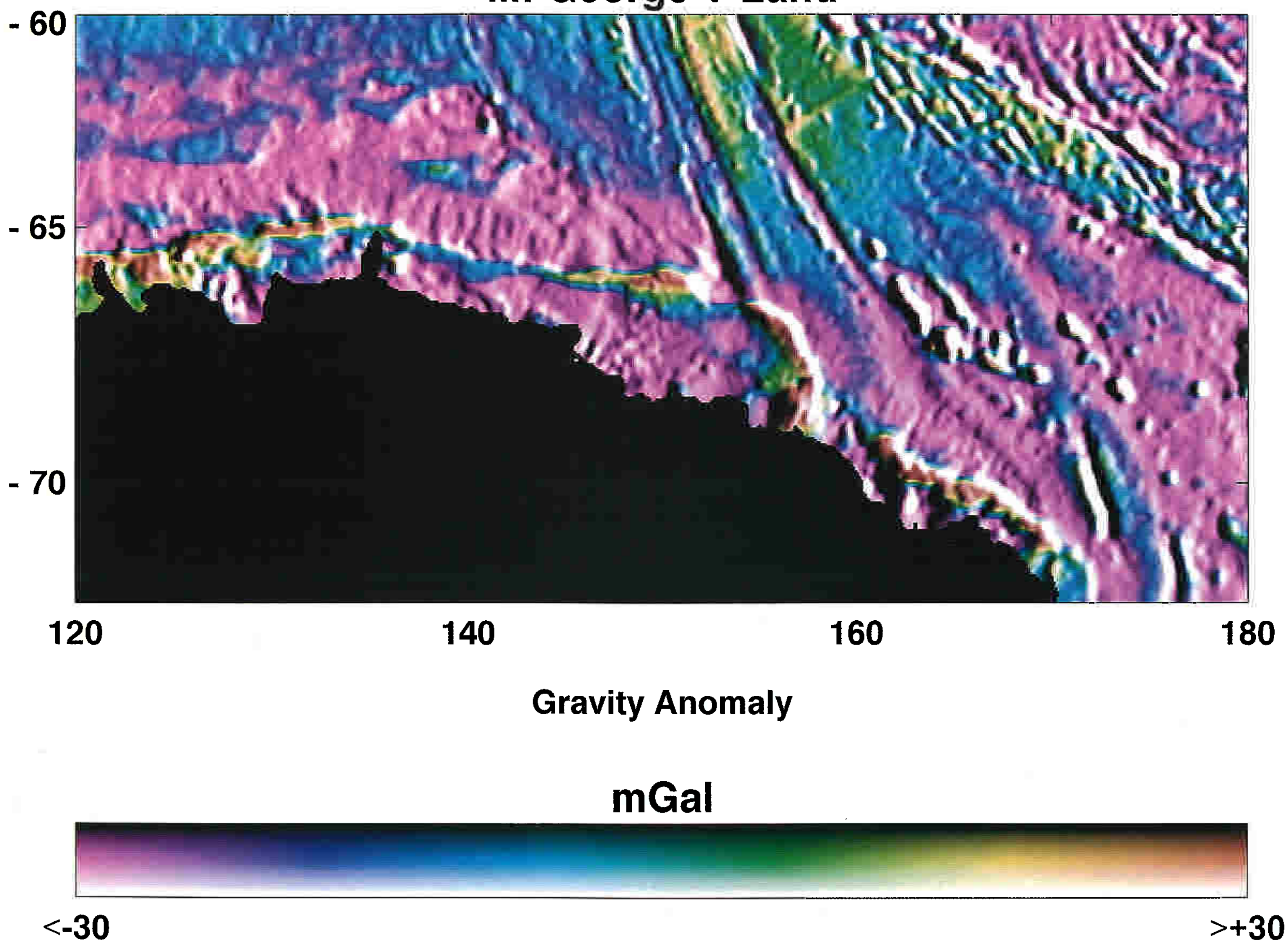



III: George V Land
- 60
- 65
- 70
120
140
160
180
Ascending Deflections
microradians
<-30
>+30

III: George V Land



III: George V Land



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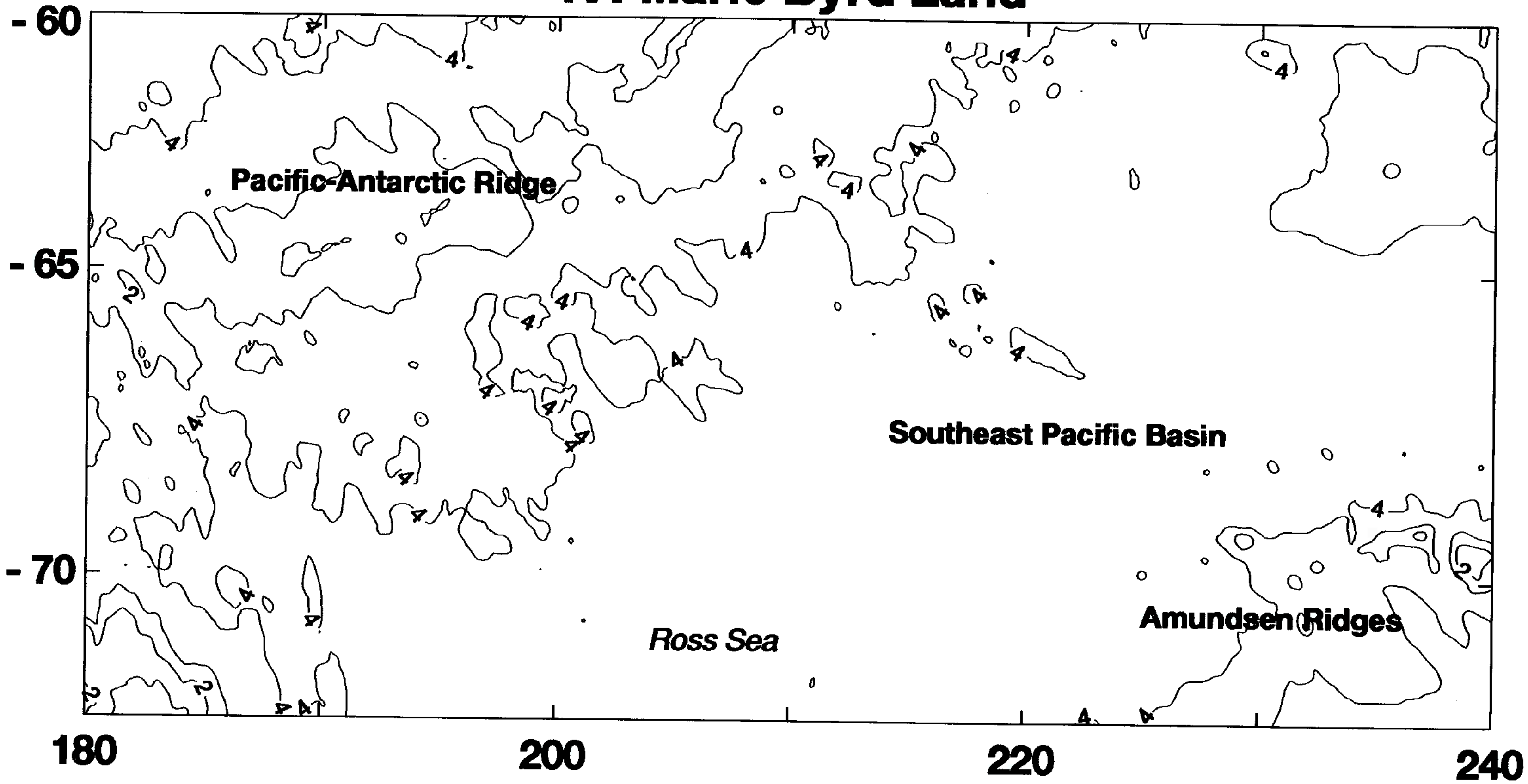
IV: Marie Byrd Land

The Marie Byrd Land region lies between 180° and 240° E longitude. The intermediate-spreading rate (~65-70 mm/yr) Pacific-Antarctic ridge traverses this region, and to the south of it lies the Southeast Pacific basin. Although region IV is devoid of land or grounded ice, the Geosat data coverage is incomplete due to sea ice which persisted from 1985 through 1986, particularly over parts of the northeastern Ross Sea. However, during the ERM (1986-1990), Geosat data coverage extended further southward into the Ross Sea than it did during the GM. Fortunately, the data coverage over the Pacific-Antarctic ridge and ridge flanks is dense.

The high-resolution gravity field clearly depicts the spreading ridge, which is associated with a positive gravity anomaly. Furthermore, the fine-scale resolution reveals that most of the ridge segments are characterized by axial highs (gravity highs), although the segment between 185° and 190° E is characterized by an axial valley (gravity low). A large southwesterly-pointing propagating rift is located on the ridge axis at 195° E. Other older propagating rifts that have been split apart by seafloor spreading are located on the ridge flanks. For example, the arms of two northeasterly-pointing propagating rifts are located south of FZ XII (which crosses the spreading ridge at 190° E), and there is evidence for others (Marks and McAdoo, 1991). The large fracture zones that cross the Pacific-Antarctic ridge are associated with gravity anomaly lows and, because these fracture zones are roughly orthogonal to the descending Geosat passes, they are particularly evident in the image of descending deflections. These fracture zones twist and bend symmetrically about the ridge axis in response to past changes in the pole of rotation. A portion of the Udintsev fracture zone is located in the northeast corner of the region, and in the southeast corner there are local gravity anomaly highs that are associated with the Amundsen ridges.

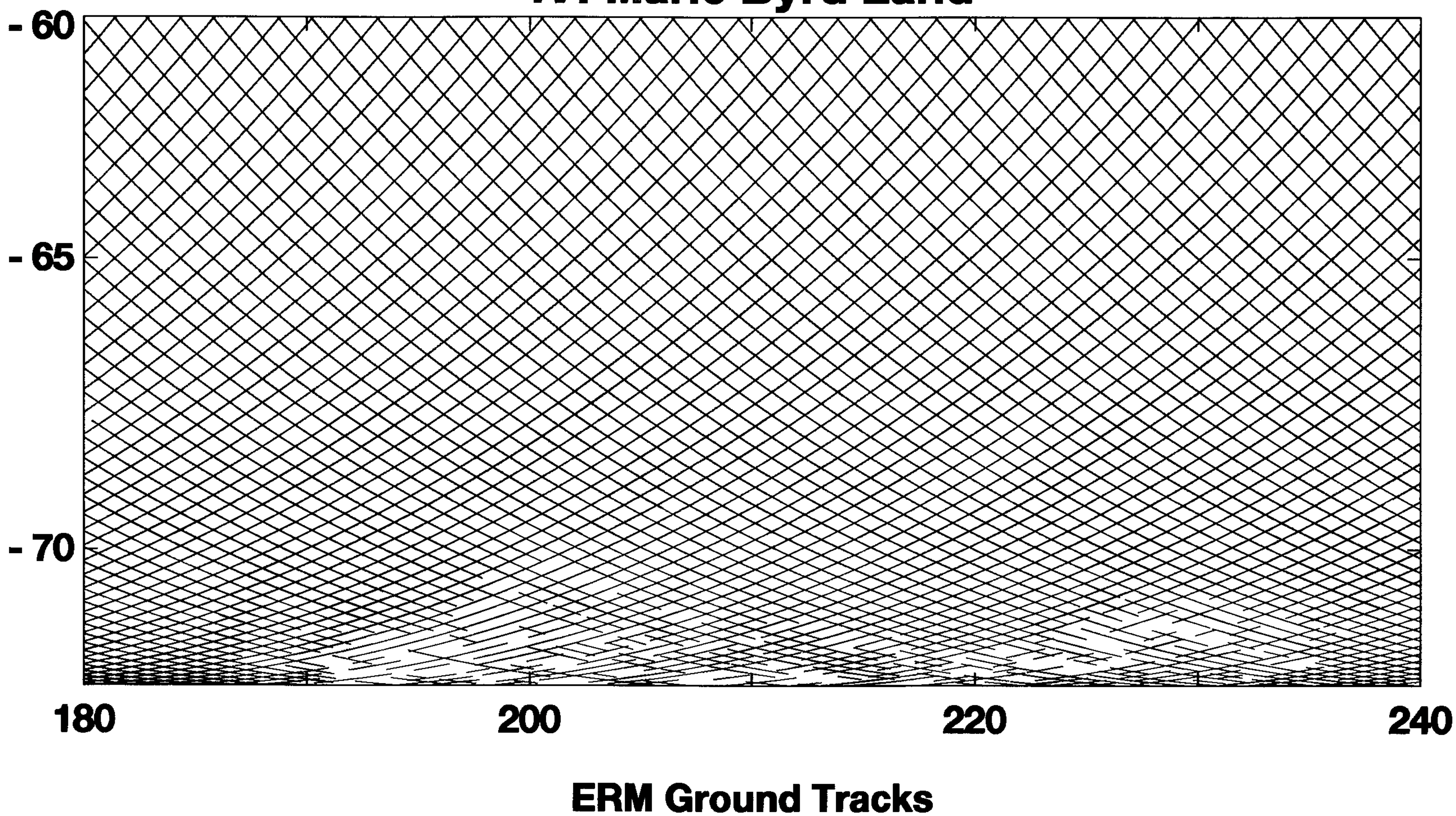
The early development of the Pacific-Antarctic ridge can now be deciphered in the high resolution gravity field (Marks and Stock, manuscript in preparation). The New Zealand microcontinent (including the Chatham rise and Campbell plateau) is believed to have broken off West Antarctica along the Marie Byrd Land margin during the Cretaceous (Mayes et al., 1990). The existence of several additional tectonic plates which moved relative to the Pacific and Antarctic plates during the early Tertiary has been proposed. For example, Stock and Molnar (1987) proposed a Bellingshausen plate which was active in the early Tertiary but 'froze' to the Antarctic plate in the mid-Tertiary. Clear traces of this Bellingshausen plate are not evident in our color images, perhaps owing to the persistent sea ice and the consequently poor Geosat coverage of the southernmost portions of Region IV.

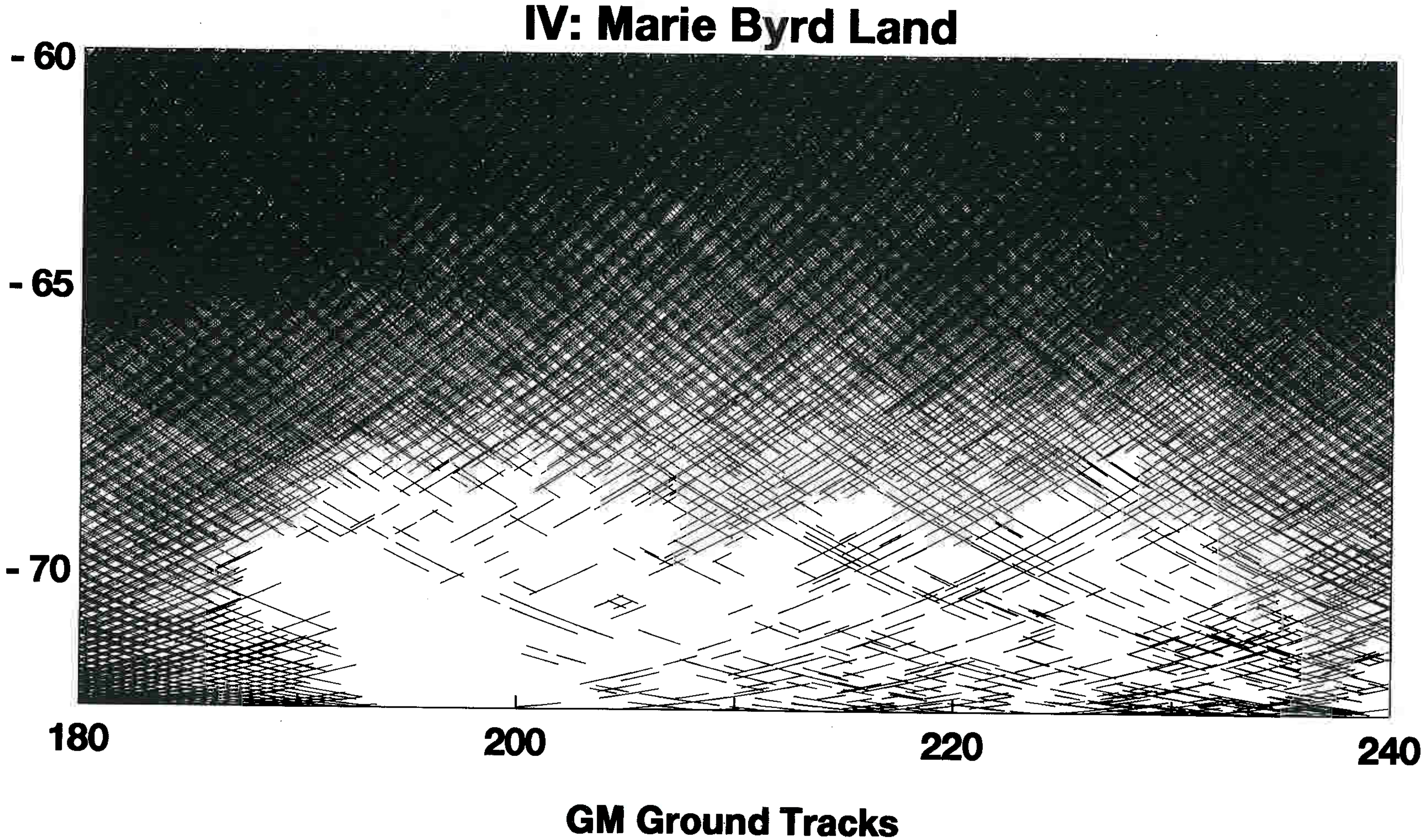
IV: Marie Byrd Land

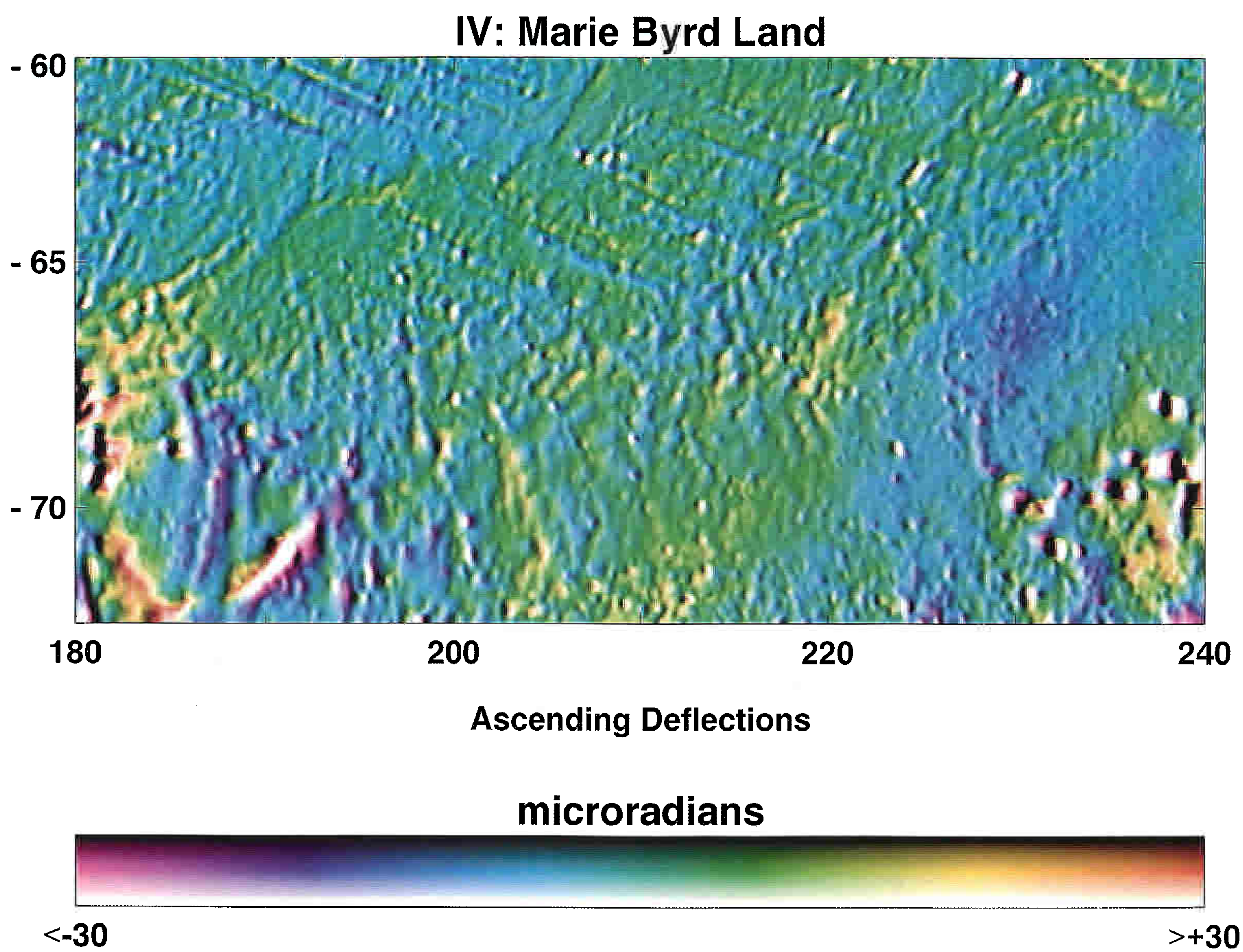


Bathymetry

IV: Marie Byrd Land




IV: Marie Byrd Land
- 60
- 65
- 70
180
200
220
240
GM Ground Tracks


IV: Marie Byrd Land
- 60
- 65
- 70
180
200
220
240
Ascending Deflections
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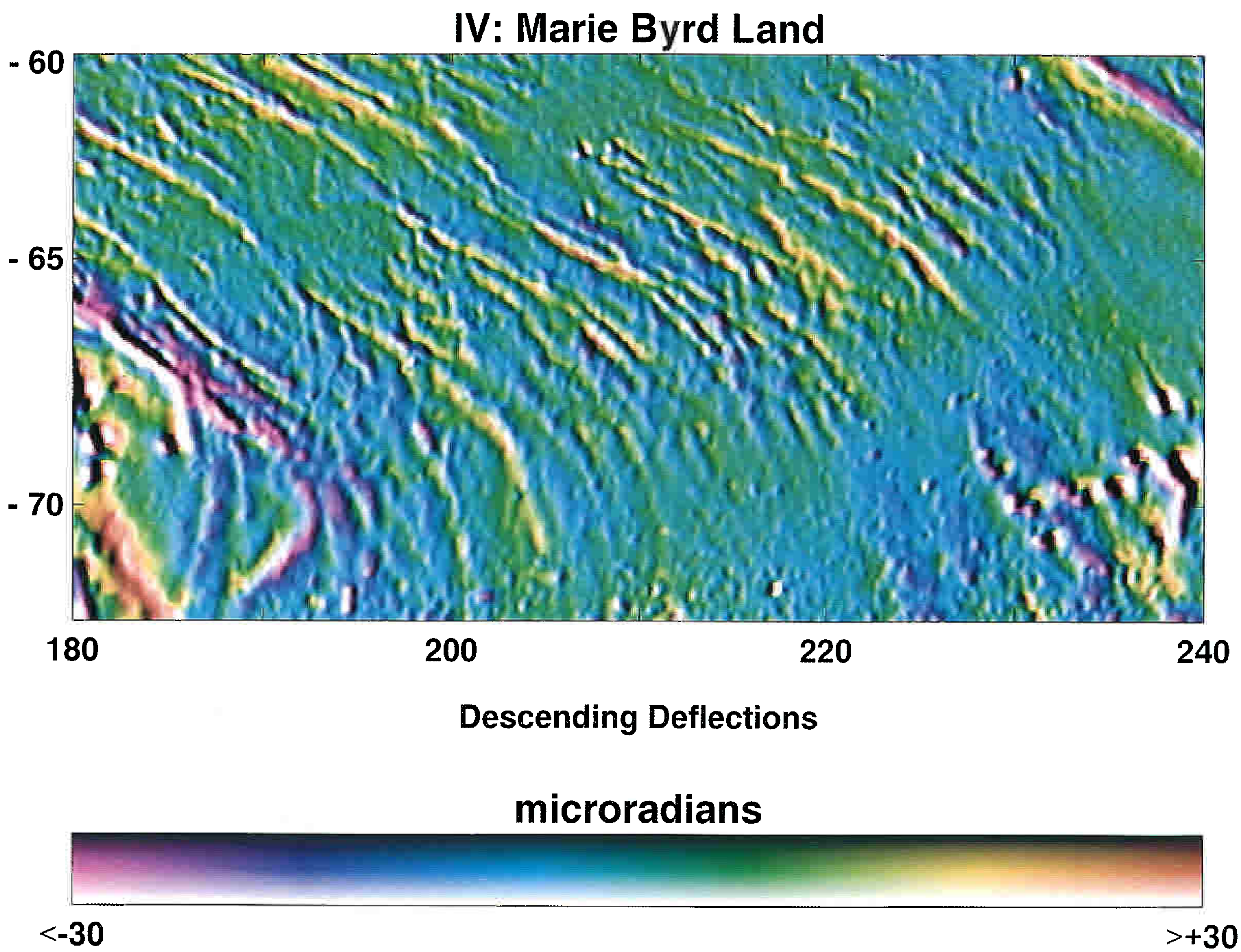
<-30
>+30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- 65
- 70
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200
220
240
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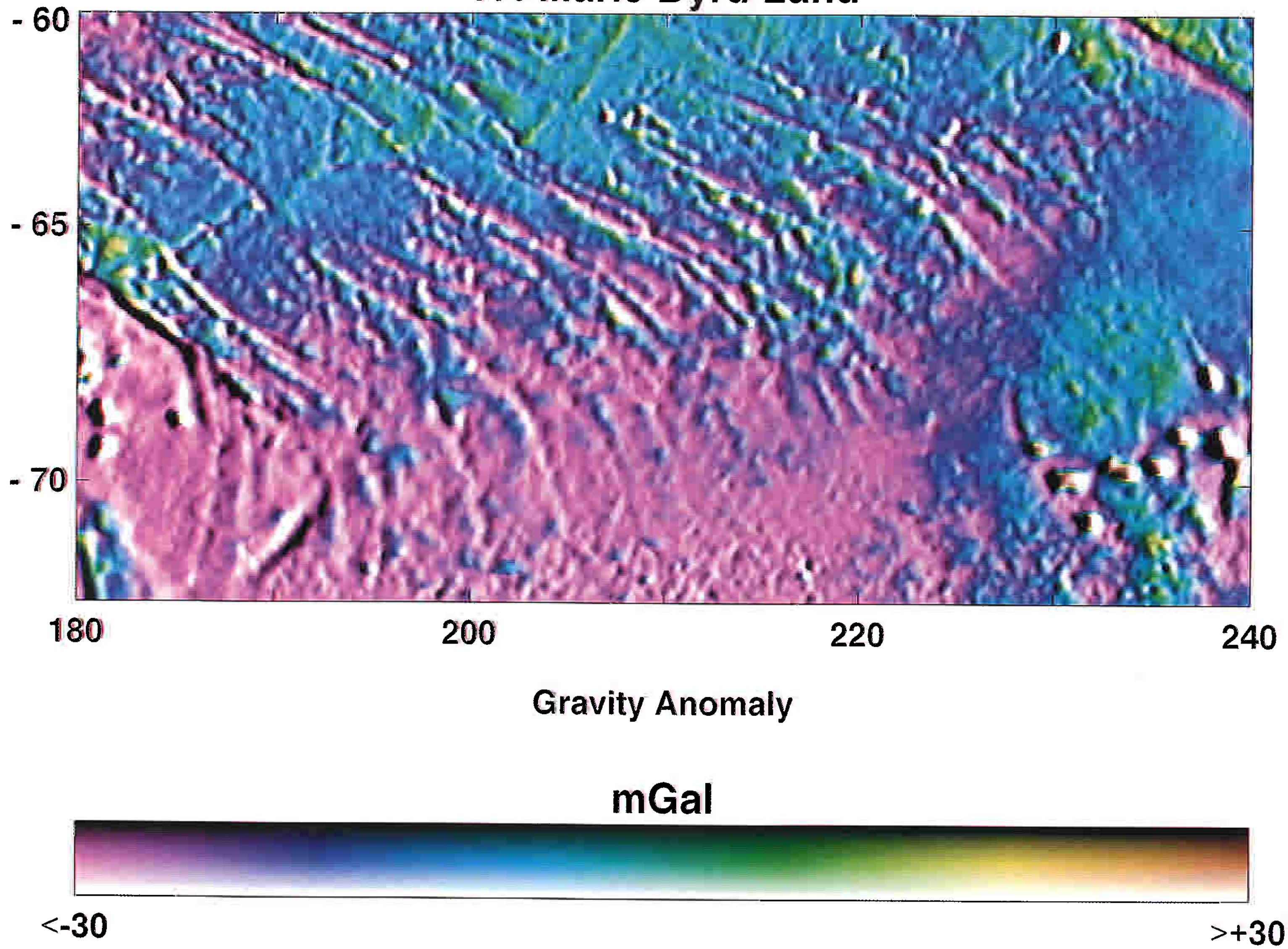
microradians
<-30
>+30

IV: Marie Byrd Land



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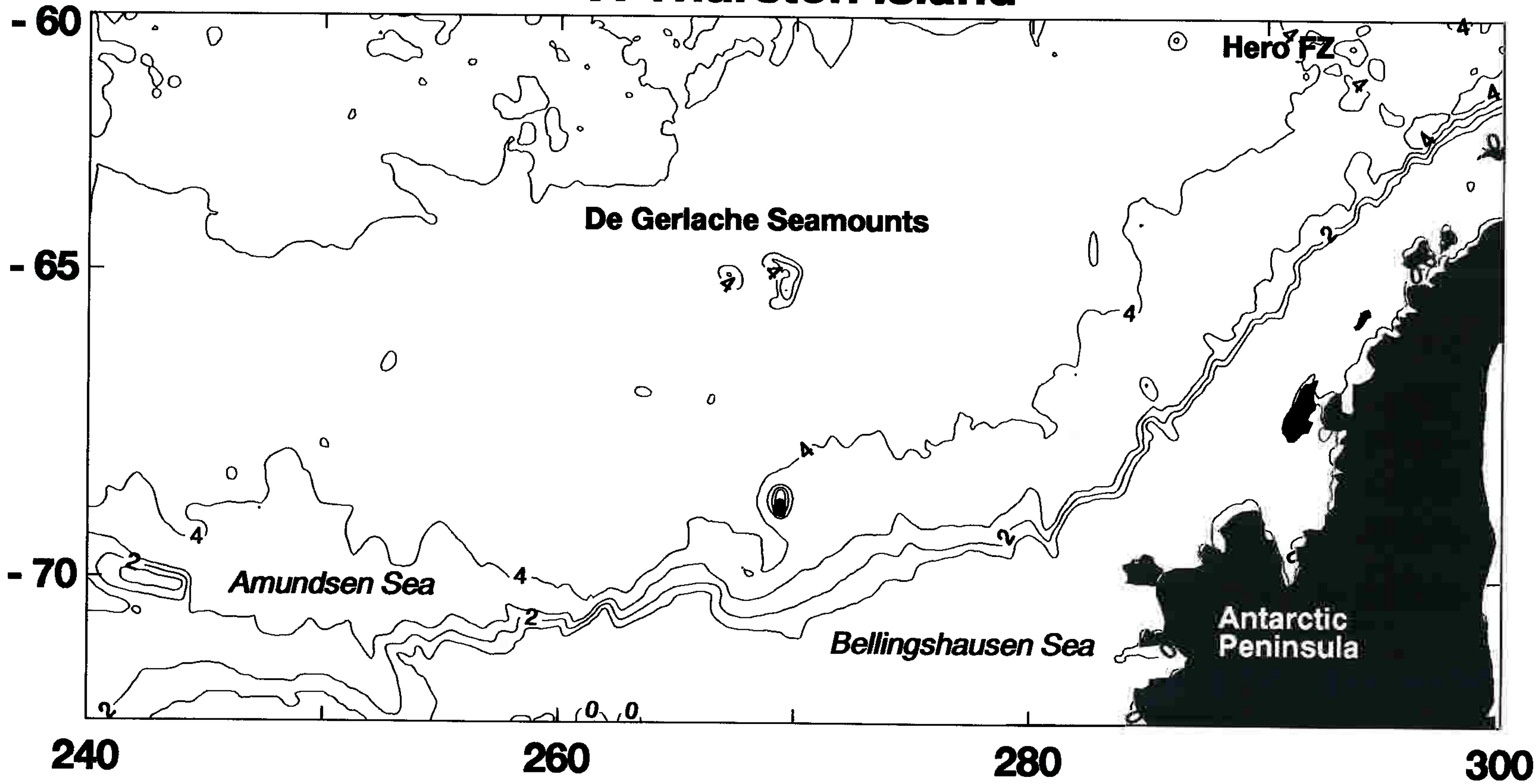
V: Thurston Island

The Thurston Island region spans 240° to 300° E longitude, and encompasses the Amundsen and Bellingshausen Seas. Both the ERM and GM data coverage is sparse south of about 70° S, and also along the west coast of the Antarctic Peninsula, but the coverage is complete elsewhere. A prominent feature in the deflections and the gravity field is a north-south trending ridge of uncertain origin (at 269° E). This ridge, which is associated with a gravity anomaly low, appears to split the De Gerlache seamounts. The ridge is not evident in the contour plot of bathymetry, due possibly to poor data coverage, sediment cover, or a subdued bathymetric expression. There is also an east-west trending chain of seamounts at 67° S, 265° E, that terminates against the ridge. The tails of two large southeasterly-trending fracture zones, the Tharp and the Heezen (of the Eltanin system), appear as gravity lows, and have their ends (or tips) near the ridge. Farther to the west, the tail of another large southeasterly-trending fracture zone, the Udintsev, can be seen. Between the Tharp and Udinstev fracture zones are the southern limbs of two propagating rifts, that trend generally north-south along 244° and 252° E longitude. These propagating rifts have been split apart by seafloor spreading, and their conjugate, northern limbs lie to the north of the Pacific-Antarctic ridge.

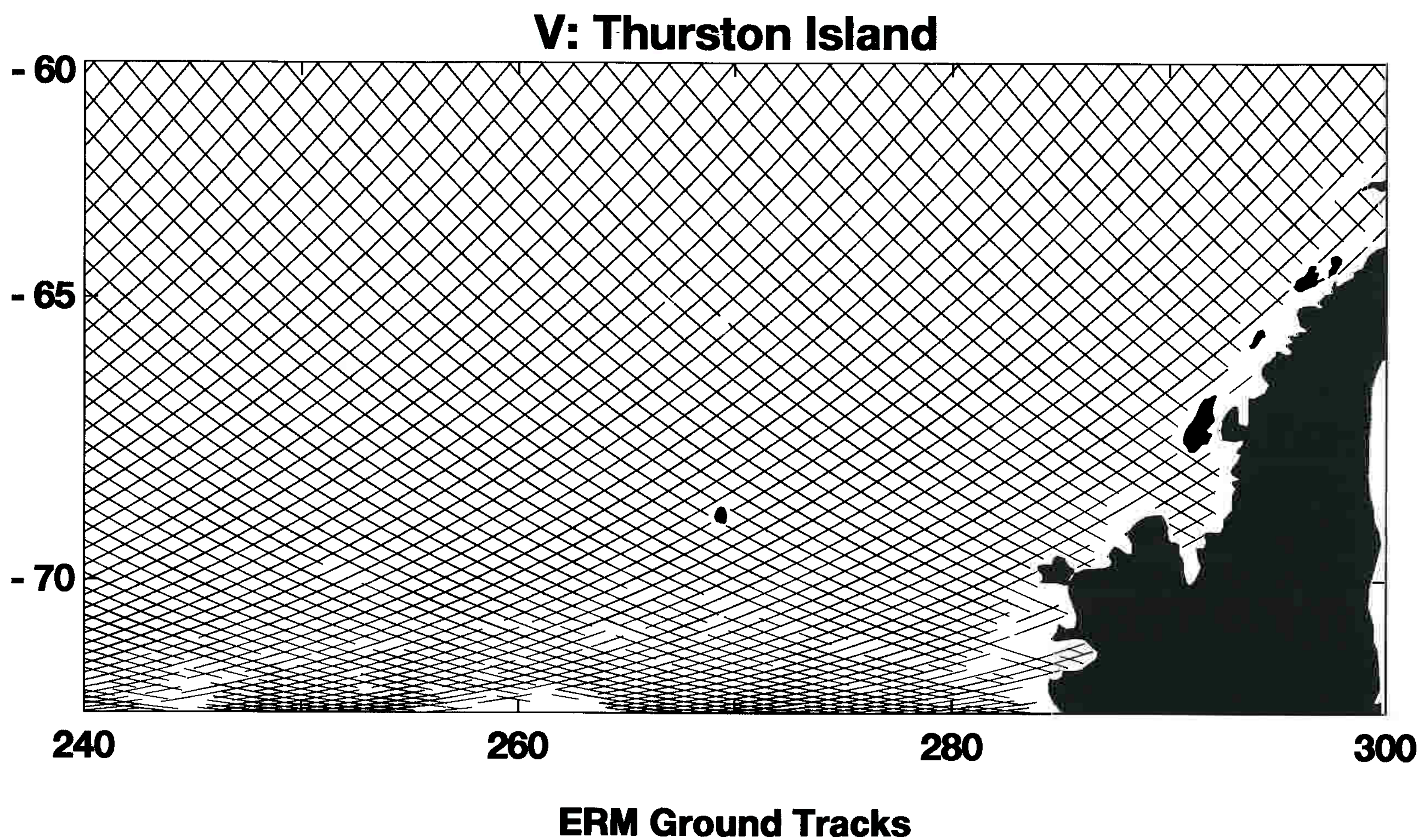
Another prominent feature in the gravity field is the South Shetland trench which lies along the northwest margin of the Antarctic Peninsula, north of 62° S. The Drake plate, a remnant of the Aluk plate, is presently (or has recently been) subducting beneath the South Shetland Islands and Bransfield Strait at this trench. The Hero FZ which presumably coincides with the southwestern boundary of the Drake plate, trends in a northwesterly direction away from the South Shetland trench at ~62° S. Parallel to, and southwest of, the Hero fracture zone are at least five more northwest-southeast trending fracture zones (including the Tula FZ) which intersect the inactive portion of the Antarctic Peninsula's western margin. These fracture zones are evident in both the images of the gravity field and the descending deflections; they were partially subducted beneath the Antarctic Peninsula during the early and mid-Tertiary when plate convergence was active along this portion of the Antarctic margin.

The tectonic features observed in the color images of this region reflect the Cretaceous rifting between West Antarctica and New Zealand, the Campbell plateau, and the Chatham rise microcontinents. Further analysis of this tectonic fabric can yield additional insights into the regional plate motion history, including constraints on the nature and existence of plates such as the Aluk and the Bellingshausen. These two plates have been proposed to be separate tectonic blocks that existed throughout much of the Tertiary but are now locked into the Antarctic plate (Mayes et al., 1990).

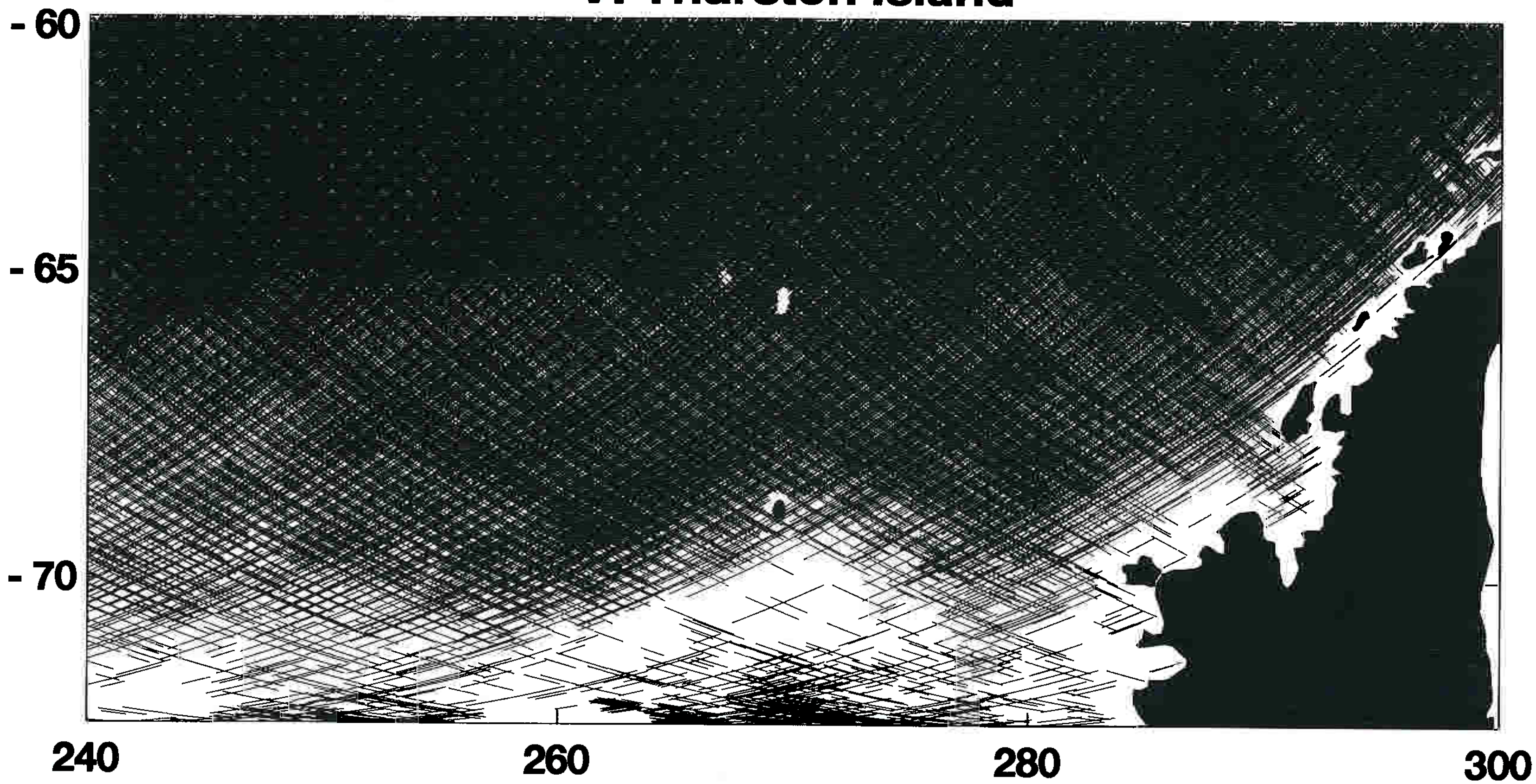
V: Thurston Island



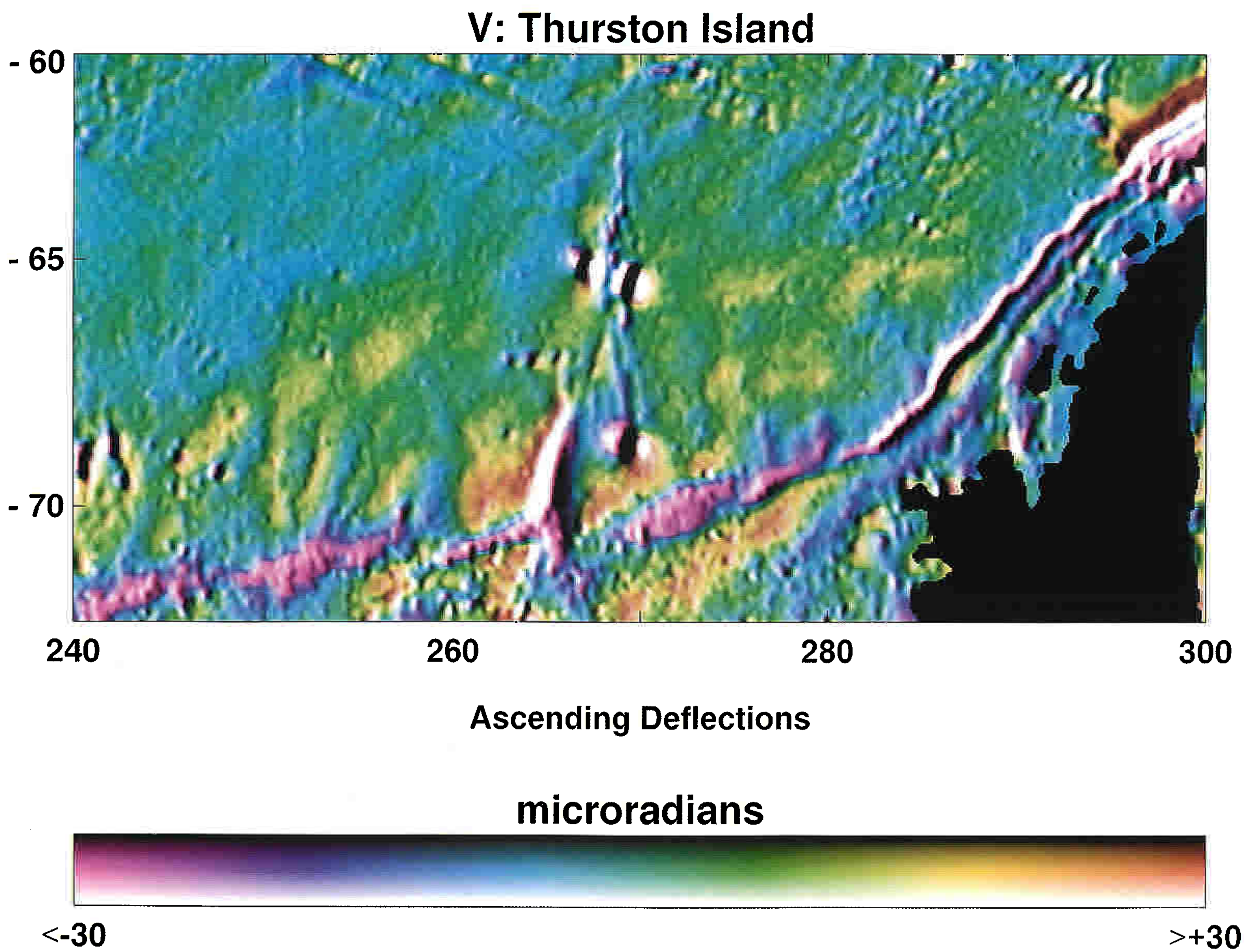
Bathymetry

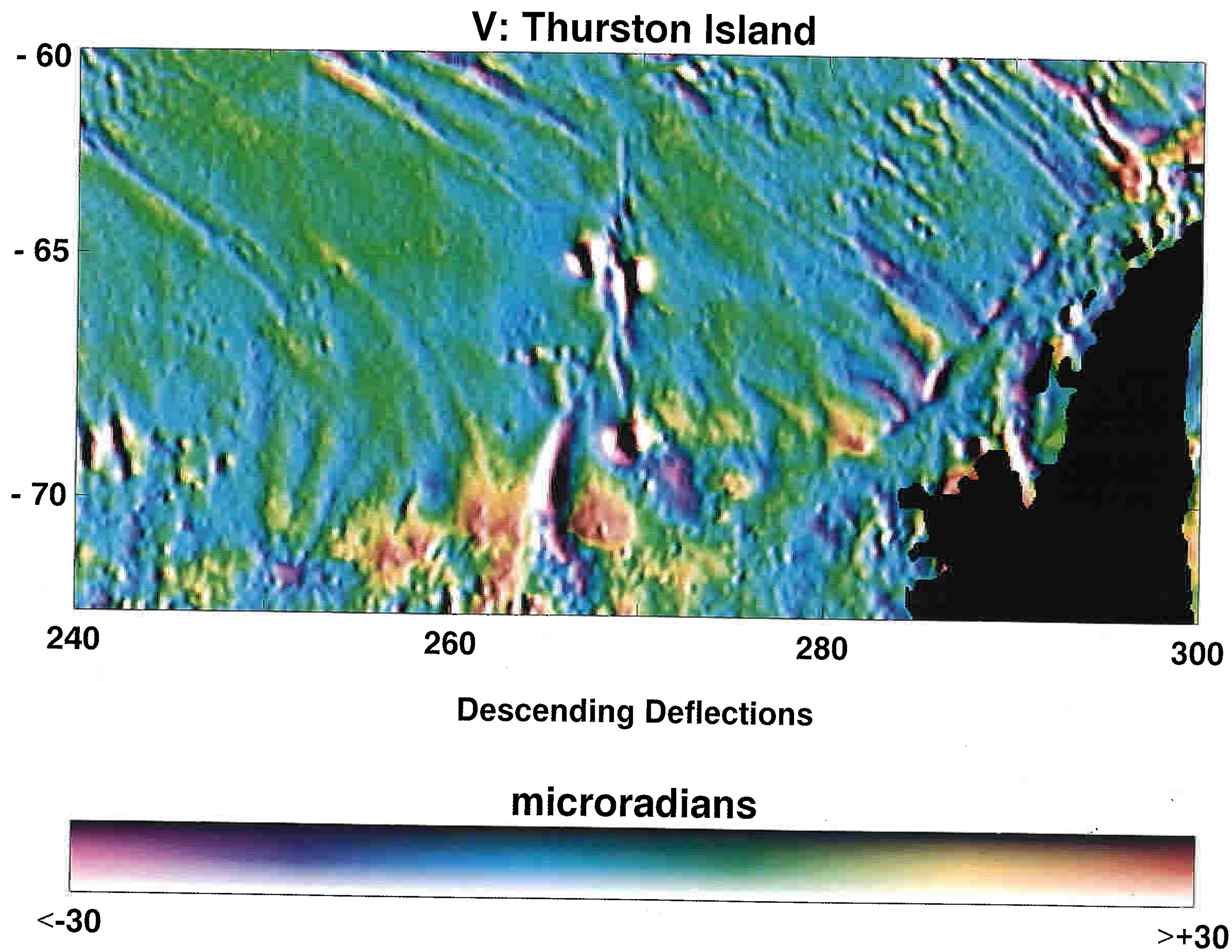

V: Thurston Island
- 60
- 65
- 70
240
260
280
300
ERM Ground Tracks

V: Thurston Island

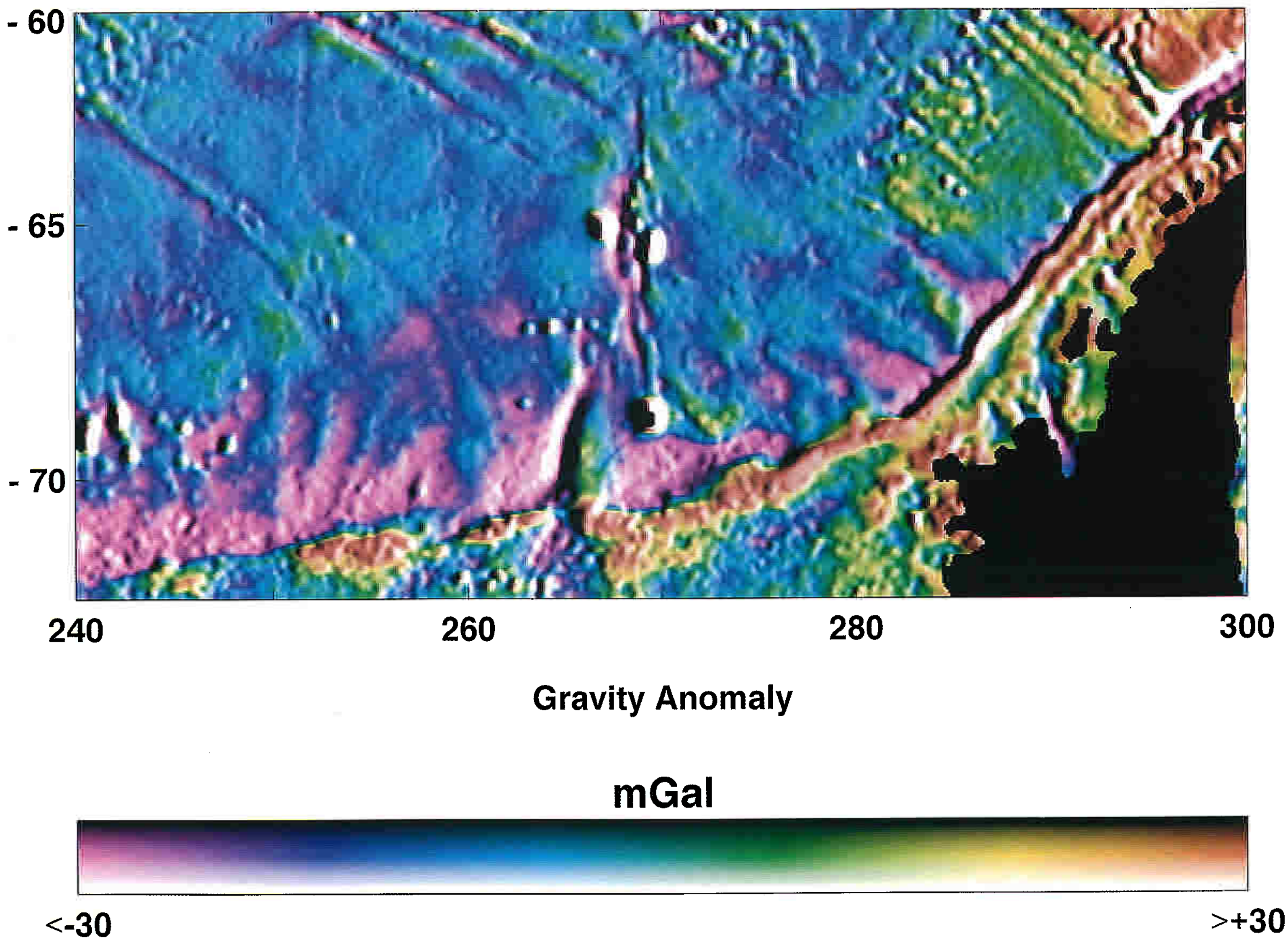


GM Ground Tracks


V: Thurston Island
- 60
- 65
- 70
240
260
280
300
Ascending Deflections
microradians
<-30
>+30


V: Thurston Island
- 60
- 65
- 70
240
260
280
300
Descending Deflections
microradians
<-30
>+30

V: Thurston Island



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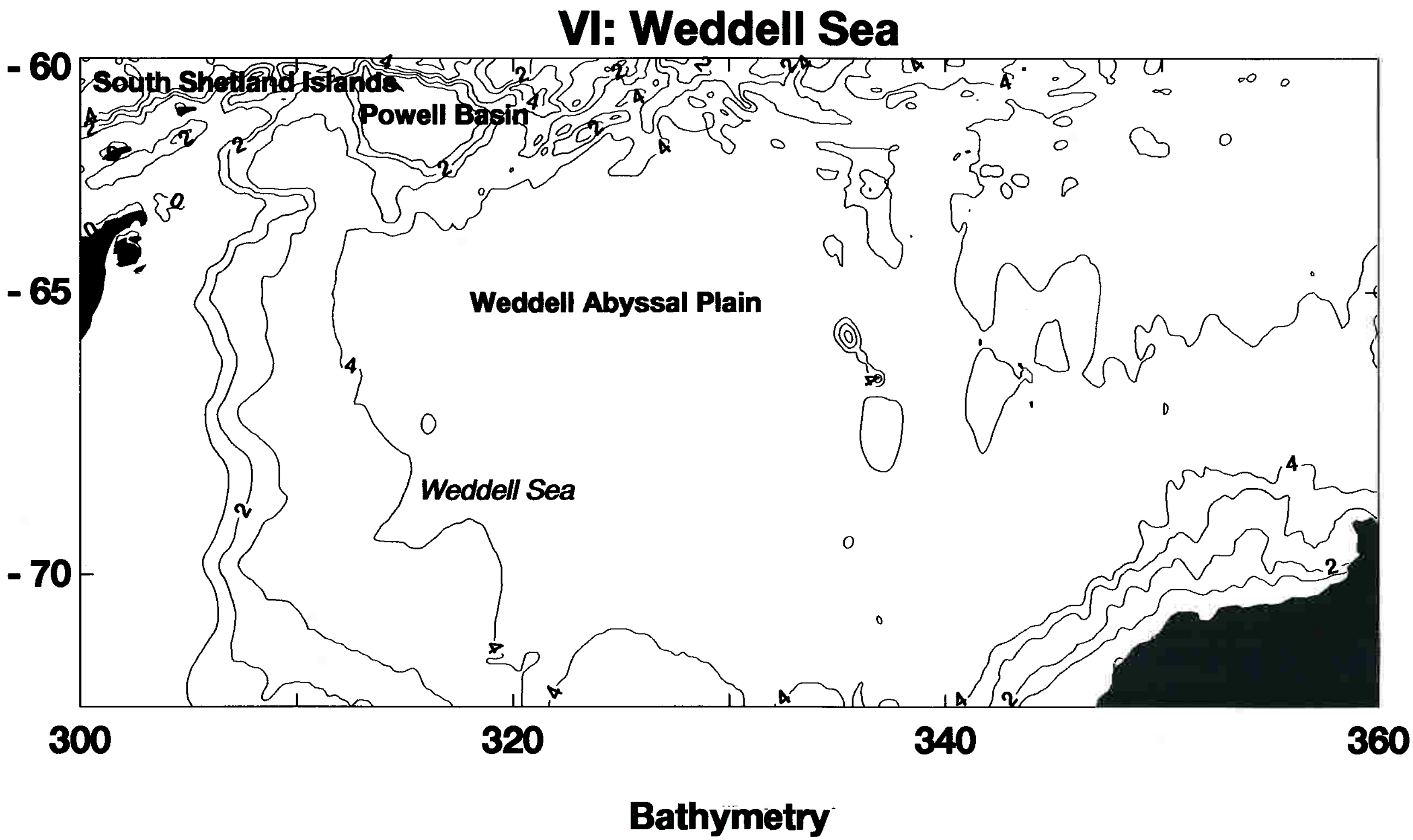
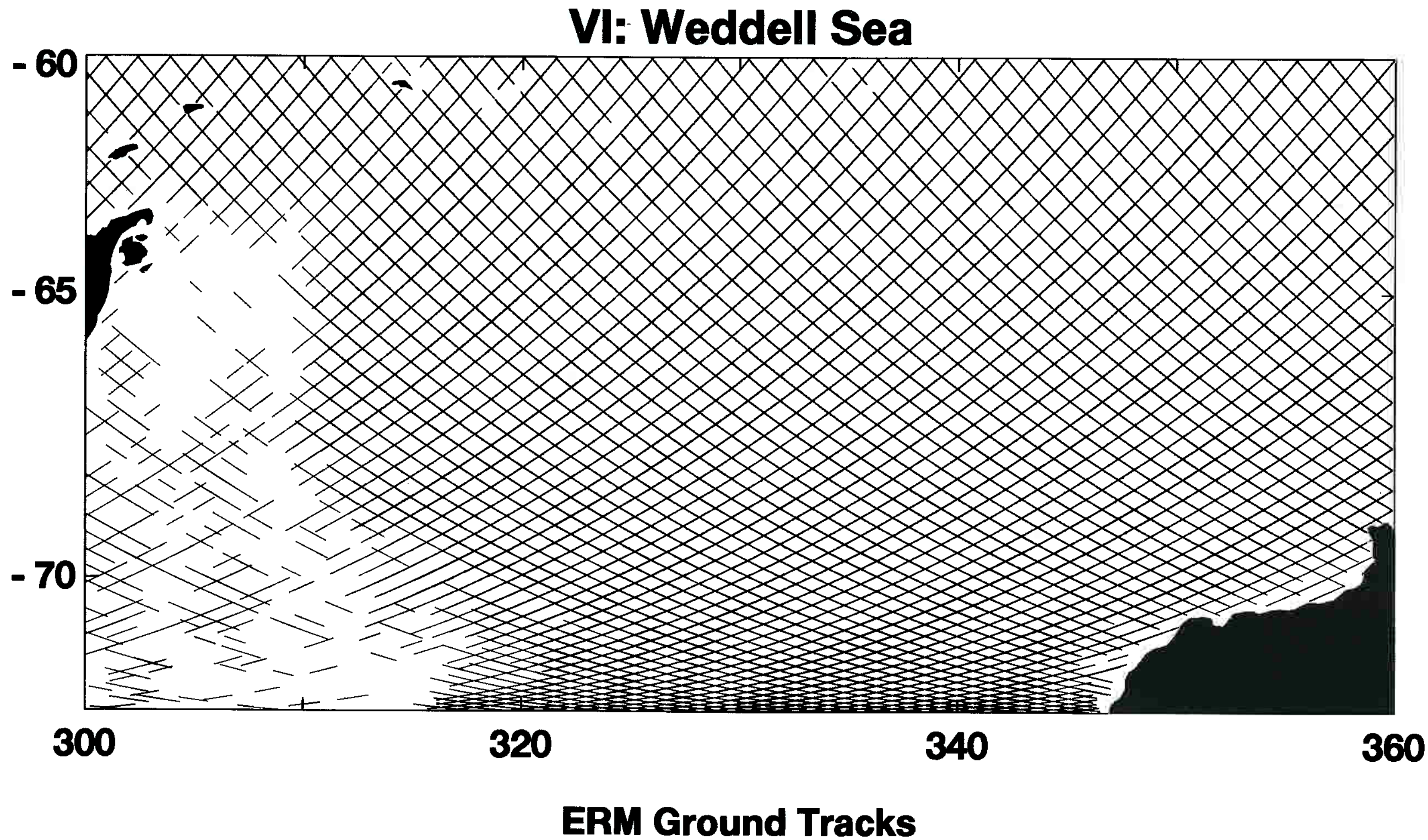
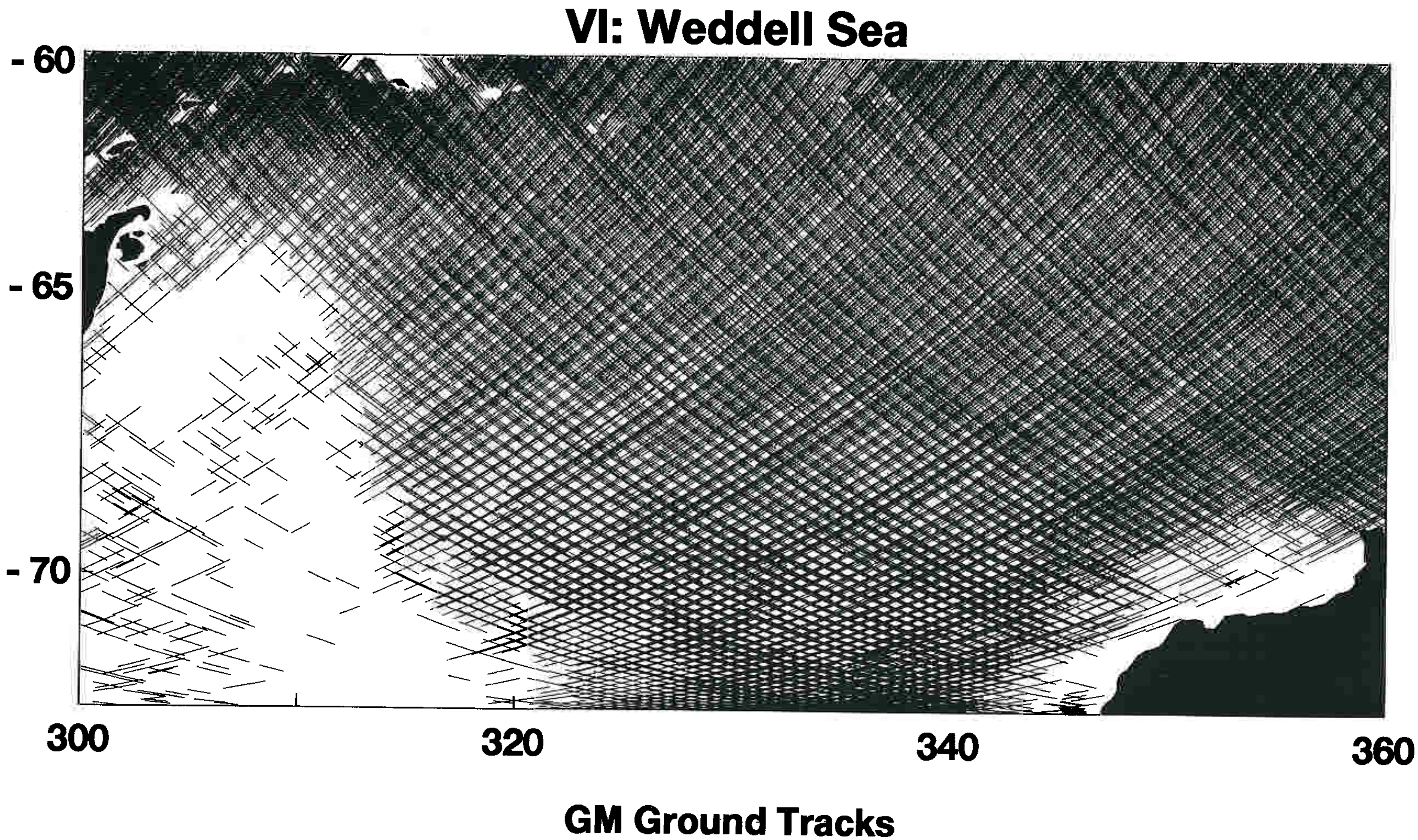
VI: Weddell Sea

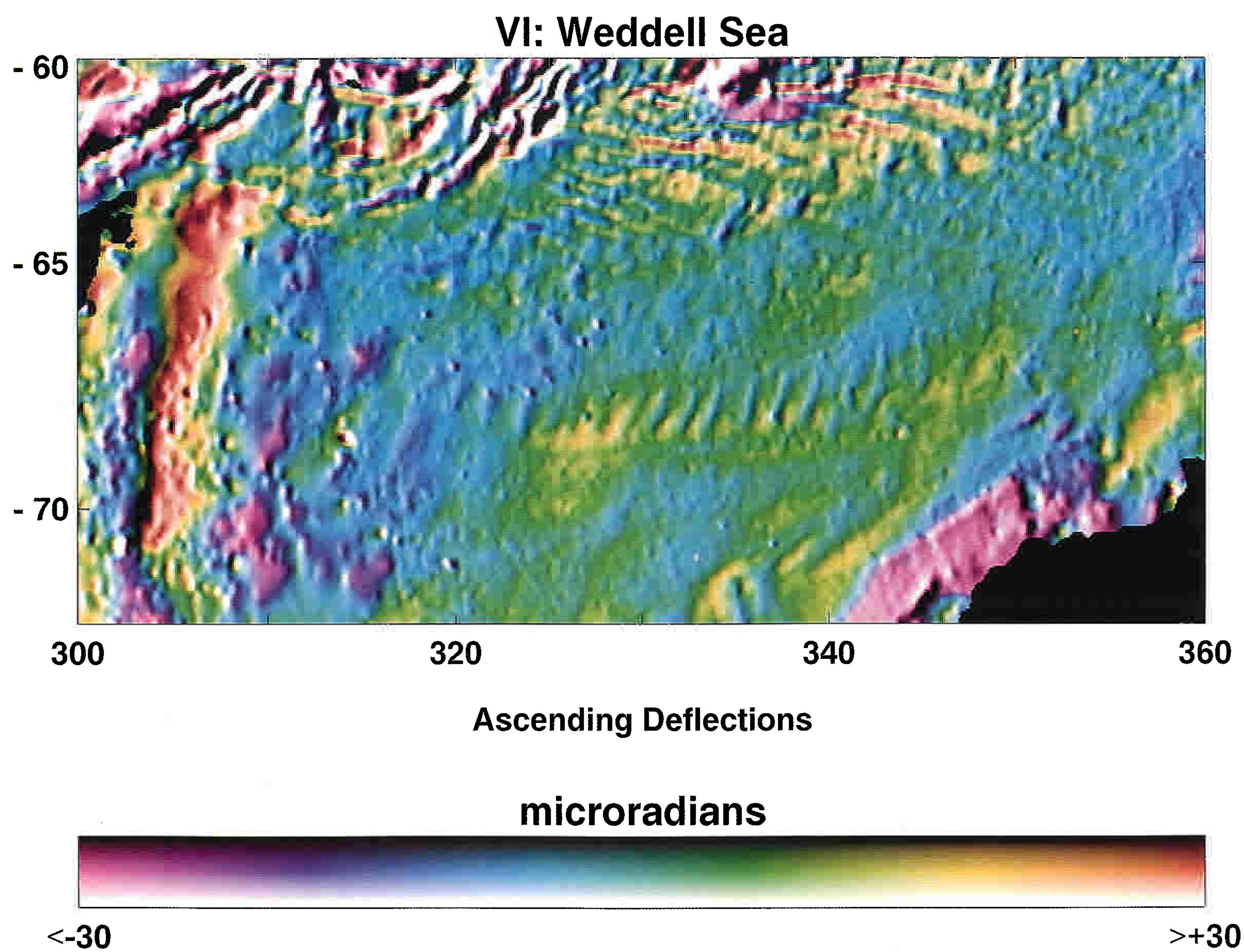
The Weddell Sea region is located between 300° and 360° E longitude, and encompasses the Weddell Sea and the Weddell abyssal plain. The ERM and GM data coverage, although dense in the east, central, and north Weddell Sea, is virtually absent over much of the western Weddell Sea, i.e., from the Antarctic Peninsula eastward to ~310° E, because of persistent sea ice. Note that some marine data were collected between 300° E and ~310° E because polynyas occasionally opened in the western Weddell Sea. In this region where data coverage is so sparse, the deflection and gravity anomalies are largely manufactured by the interpolation algorithm. However, in the east and central Weddell Sea where the satellite coverage is dense, one can see lineated small-scale gravity and deflection anomalies which form a fish-skeleton pattern in the color images. North of 67° S, these anomalies trend generally northwest-southeast, and south of 67° S they trend northeast-southwest. It is likely that these anomalies are the expression of old fracture zones that formed on spreading ridges that are now extinct (and probably subducted). The obvious variations in the trend of these fracture zones indicates a complex history of spreading between West Antarctica and South America.

Other features of tectonic importance can be seen in the images of gravity and deflections of the vertical for this region. In the northwest corner, one can view the eastern end of the South Shetland trench (a gravity low) which is intersected by the northwest-trending Shackleton fracture zone. To the southeast of the South Shetland trench and Islands is the Bransfield Strait. East of the Bransfield Strait is the Powell basin whose southern edge is clearly outlined by a concave northward, arcuate gravity high which extends from about 305° E to 325° E longitude. The northern edge of the Powell basin is formed by the South Scotia fault which trends east-west along ~61° S (between 310° and 335° E). At 335° E, and about 60° S, the southern end of the South Sandwich trench can be seen in both the gravity anomaly and ascending deflection images. This trench forms the boundary between the South American and Sandwich plates. Also, between 335° E and 346° E, along the 61° S parallel, the east-west trending South Sandwich transform manifests itself very clearly. This transform acts as a portion of the plate boundary between the South American and Antarctic plates.

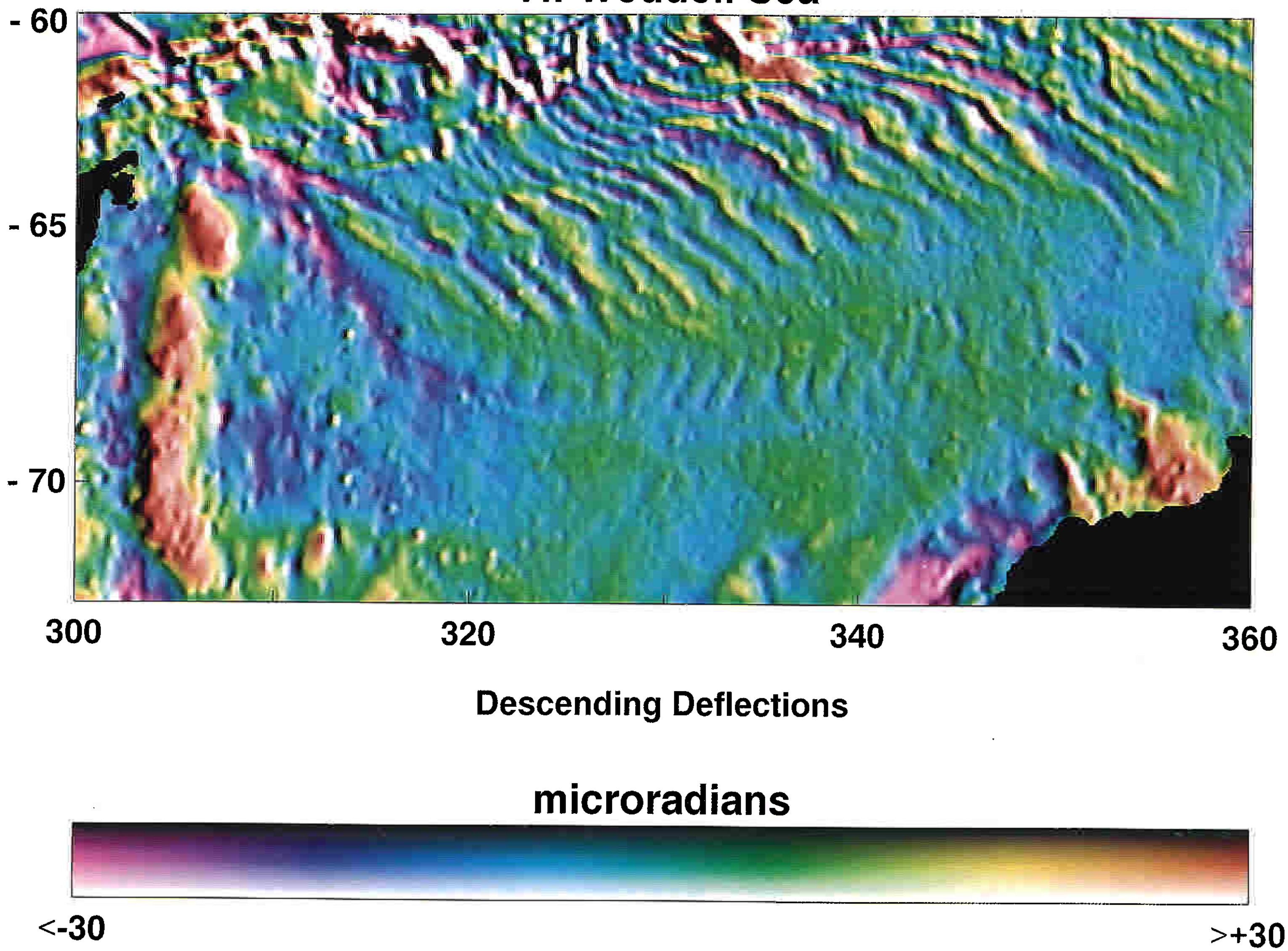

VI: Weddell Sea
South Shetland Islands
Powell Basin
Weddell Abyssal Plain
Weddell Sea
- 60
- 65
- 70
300
320
340
360
Bathymetry


VI: Weddell Sea
- 60
- 65
- 70
300
320
340
360
ERM Ground Tracks

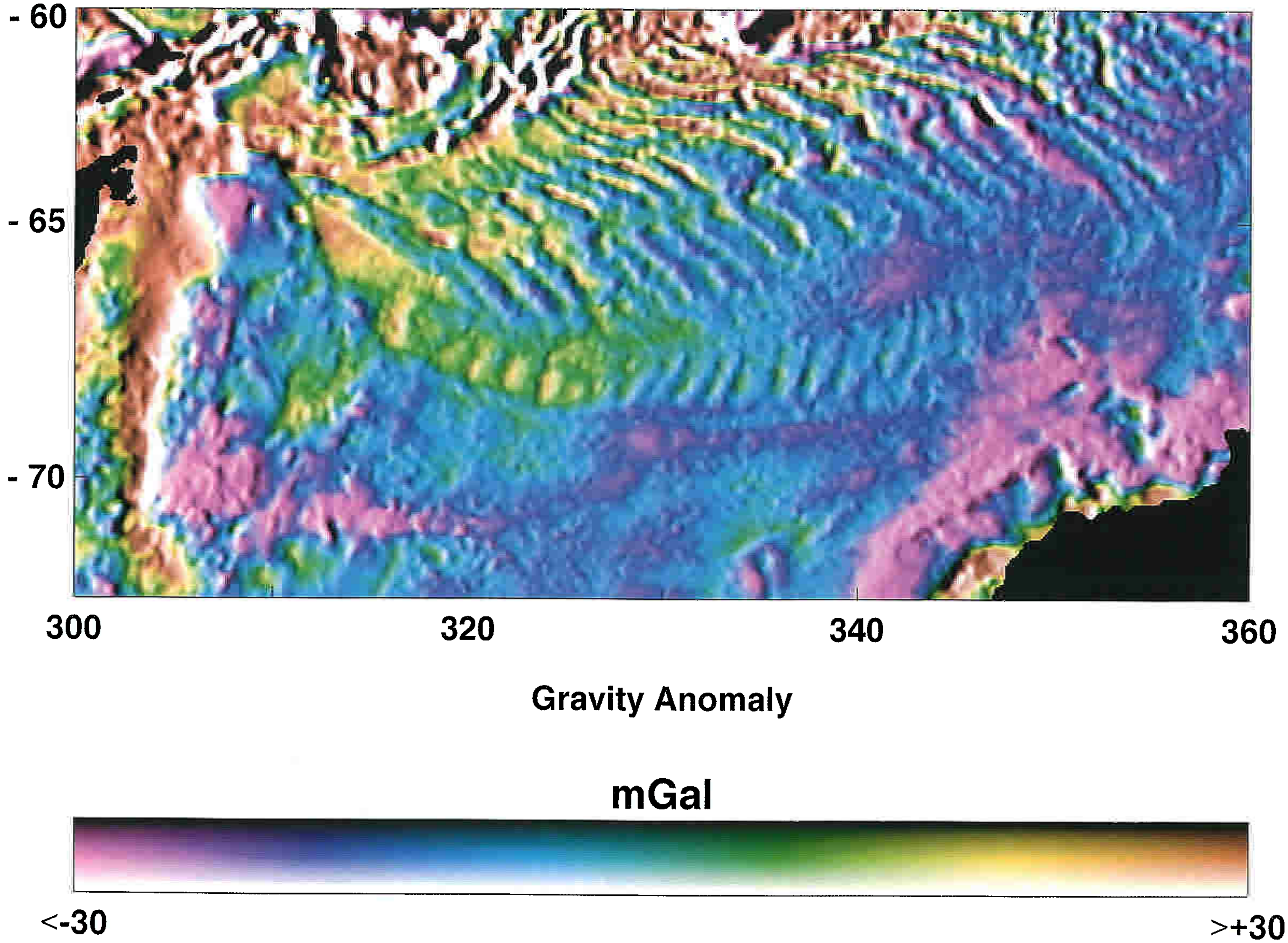

VI: Weddell Sea
- 60
- 65
- 70
300
320
340
360
GM Ground Tracks


VI: Weddell Sea
- 60
- 65
- 70
300
320
340
360
Ascending Deflections
microradians
<-30
>+30

VI: Weddell Sea



VI: Weddell Sea



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Summary

We have shown plots of bathymetry and of Geosat ground track coverage, as well as images of deflections of the vertical (both ascending and descending), and gravity anomalies for the region encircling Antarctica between 60° and 72° S. Release of the previously classified, high-density Geosat GM data, combined with lower density ERM data, have permitted us to construct high resolution gravity fields over the Southern Ocean. With these results, we now have a better, more precise knowledge of the marine gravity field around Antarctica than in any other large scale region of the world's oceans. This is especially exciting because the area around Antarctica is among the world's most poorly charted by ships and airplanes.

There are potentially many geophysical applications of these results. One particularly important application is the mapping of the tectonic fabric imprinted in the seafloor and the consequent improvement in our understanding of the relative plate motions which occurred throughout the Cenozoic and late Mesozoic Eras following the breakup of the supercontinent Gondwana.

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References

Cheney, R. E., Doyle, N. S., Douglas, B. C., Agreen, R. W., Miller, L., Timmerman, E. L., and McAdoo, D.C., 1991: The complete Geosat altimeter GDR handbook, *NOAA Man. NOS NGS-7*, National Ocean Service, Rockville, MD.

Cheney, R., Douglas, B., Agreen, R., Miller, L., Milbert, D., and Porter, D., 1986: The GEOSAT altimeter mission: A milestone in satellite oceanography, *EOS Trans. AGU, 67*, 1354-1355.

Marks, K. M. and McAdoo, D. C., 1992: Gravity field over the Southern Ocean from Geosat (poster), Nat. Geophys. Data Center, World Data Center-A for Marine Geol. and Geophys., *Rep. MGG-6.*

Marks, K. M. and McAdoo, D. C., 1991: Tectonic development of the Pacific-Antarctic ridge (abstract), *EOS Trans. AGU, 72*, 266.

Marks, K. M., McAdoo, D. C., and Sandwell, D. T., 1991: Geosat GM data reveal new details of ocean floor, *EOS Trans. AGU, 72*, 145-149.

Mayes, C. L., Lawver, L. A., and Sandwell, D. T., 1990: Tectonic history and new isochron chart of the South Pacific, *J. Geophys. Res., 95*, 8543-8567.

McAdoo, D. C., and Marks, K. M., 1992: Gravity fields of the Southern Ocean from Geosat data, *J. Geophys. Res., 97*, 3247-3260.

McAdoo, D. C., and Marks, K. M., 1991: Evidence for a more extensive east Antarctic ice sheet in recent time from Geosat marine altimetry (abstract), *EOS Trans. AGU, 72*, 91.

Norton, I. O., and Sclater, J. G., 1979: A model for the evolution of the Indian Ocean and the breakup of Gondwanaland, *J. Geophys. Res., 84*, 6803-6830.

Recq, M., and Charvis, P., 1986: A seismic refraction survey in the Kergulelen Isles, southern Indian Ocean, *Geophys. J. R. astr. Soc., 84*, 529-559.

Stock, J., and Molnar, P., 1987: Revised history of early Tertiary plate motion in the south-west Pacific, *Nature, 325*, 495-499.