

A high-resolution aeromagnetic survey over the Cape Roberts Rift Basin: Correlations with seismic reflection and magnetic susceptibility log data

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Summary A high-resolution aeromagnetic survey (altitude 125 m asl, spacing 500 m, area 800 km²) was carried out in 1994 offshore of Cape Roberts by the GITARA (German ITALian Aeromagnetic Research in Antarctica) Group. The availability from drilling of whole-core physical properties logs for magnetic susceptibility, P-wave velocity and density/porosity data allows new insights to be inferred from reprocessed and reviewed HRAM aeromagnetic data. Aeromagnetic data have been reprocessed to image with greater detail the structural framework along the western flank of the Victoria Land Basin. New processing includes 2D Werner and 3D Euler deconvolution, the production of maps of the maximum horizontal gradient of pseudo-gravity, and 2D, 3D modelling. Magnetic trends and anomalies are discussed in conjunction with now available drilling results from the CRP, existing bathymetric data and recently published interpretations of a multichannel seismic reflection survey.

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Introduction

In 1994 we carried out a high-resolution aeromagnetic survey offshore of Cape Roberts (Bozzo et al., 1997a). Here we review the old survey data set, combining drilling information, seismic and magnetic data, in order to achieve a better understanding of the structure of the Cape Roberts Rift Basin (CRRB).

Cape Roberts is a small outcrop in the southwestern Ross Sea, Antarctica, about 125 km north of Ross Island, on the southern flank of Granite Harbour (Figure 1). Offshore from Cape Roberts the bathymetry shows a north-south trending, 500 m-deep, trough-like feature interpreted by many authors as being the seabed expression of a graben: the Cape Roberts Rift Basin (Figure 2). This deep graben is bounded by the Transantarctic Mountains (TAM) foothills, to the west, and by a submerged bathymetric high (~100 m bsl), the Roberts Ridge, to the east. To the north the CRRB is abruptly truncated by the WSW-ENE trending Pleistocene McKay sea valley, which reaches a depth of about 1000 m below sea level.

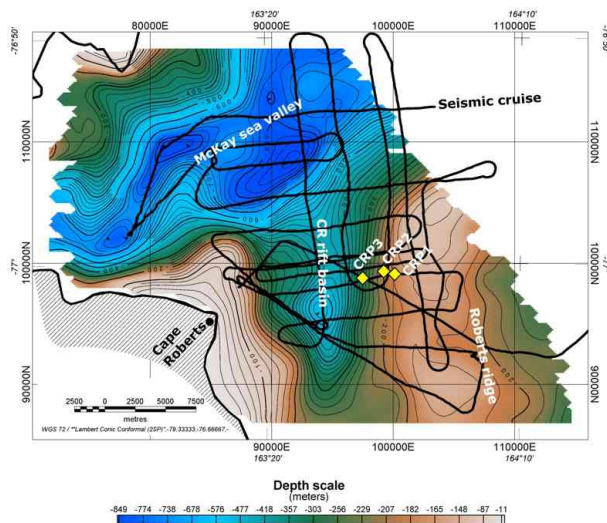
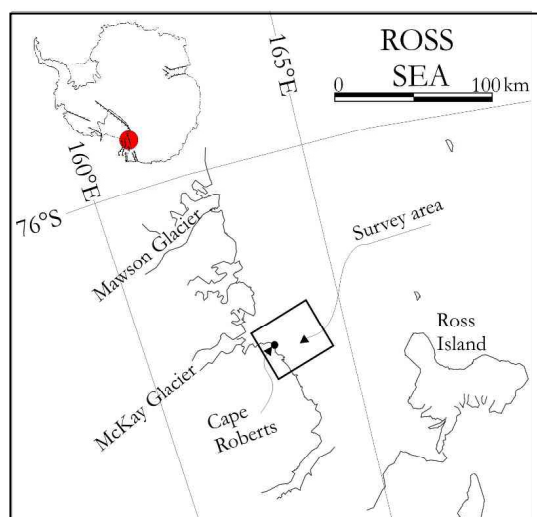


Figure 1 (left). Location of the survey area (box) in the southwest Ross Sea.

Figure 2 (right). Bathymetric image of the aeromagnetic survey area. Drilling locations and locations of seismic multichannel reflection lines are also shown (Hamilton et al., 2001).

Cape Roberts is a strategic location where the scientific international community (seven countries) has focused many efforts to investigate the early history of the East Antarctic Ice Sheet and the West Antarctic Rift System (Davey et al., 2001). A total of about 250 km of multichannel seismic reflection data were recorded along a number of lines crossing the CRRB (Figure 2), in the framework of the Cape Roberts Drilling Project (Hamilton et al., 2001). The drilling efforts recovered, over 1500 m of strata in three drill holes, representing a period ranging from 16Ma to about 34Ma. The availability from the drilling of whole-core physical properties logs for magnetic susceptibility, P-wave velocity and density/porosity data (e.g. Davey et al., 2001) allows new insights to be inferred from reprocessed and reviewed high-resolution aeromagnetic (HRAM) data. Aeromagnetic data have been reprocessed to image with greater detail the structural framework of the western flank of the Victoria Land Basin. New processing includes 2D Werner and 3D Euler deconvolution, the production of maps of the maximum horizontal gradient of pseudo-gravity, and 2D, 3D modelling. Magnetic trends and anomalies are discussed in conjunction with now available drilling results from the Cape Roberts Drilling Project, existing bathymetric data and the recently published interpretations of a multichannel seismic reflection survey.

The aeromagnetic survey

The aeromagnetic survey was carried out in 1994 using the helicopter-borne aeromagnetic equipment of the Italian Antarctic Program (Bozzo et al., 1997a). The profile-line spacing was 500 m and the flight level was 150 m constant barometric altitude, corresponding to a clearance (with the sensor 25m below the helicopter) of 125 m above sea level. A magnetic base station was operated at Cape Roberts to monitor temporal magnetic variations.

Standard aeromagnetic processing included the base station correction, IGRF removal, levelling and microlevelling in the frequency domain (Ferraccioli et al., 1998). Aeromagnetic data were then reduced to the pole. Changes in the distance from the sensor to the magnetic source will lead to variable attenuation of the magnetic anomalies. This is particularly relevant since the survey spans an area from high sensor clearance over the McKay sea valley in the north, (about 1100 m clearance), to an area of high topographic elevation in the east in the Roberts Ridge where sensor clearance was only about 200 m (Figure 2). To accommodate these variations, the aeromagnetic data were draped (Pilkington and Thurston, 2001) over the topography grid (Figure 2). The resulting total field aeromagnetic anomaly map with a drape interval of 200 m is shown in Figure 3.

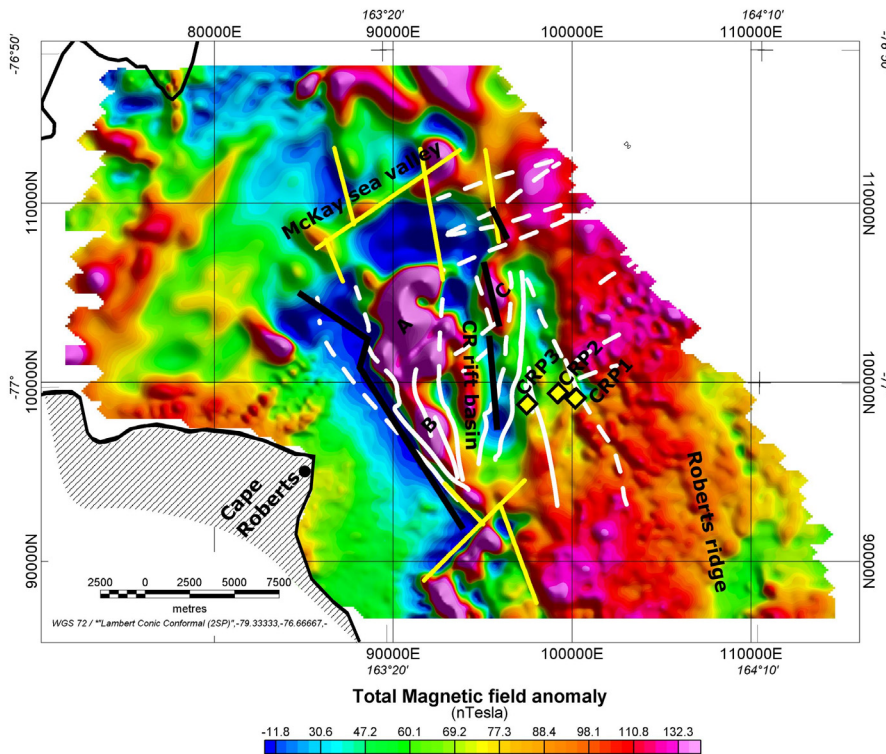


Figure 3. Draped total magnetic field anomaly map. White lines are faults at top of seismic unit V4b interpreted by Hamilton et al. (2001). Yellow lines are magnetic lineaments interpreted by Bozzo et al. (1997b).

Structural discontinuities, such as faults, subcrops, lithological contacts and depositional edges, can create lateral contrasts in magnetization of rocks, generating detectable magnetic anomalies (Glenn and Badgery, 1998, Grauch et al., 2001; Goussev et al., 2003). Many of these anomalies are sourced in the sedimentary section. Data processing techniques can enhance these subtle magnetic anomalies to make them coherent and correlatable over large areas. To enhance magnetic lineaments, we have applied the Goussev filter (Goussev et al., 1998, 2003), a space-domain operator that calculates the scalar difference between the total magnetic-field gradient and its horizontal component. The resulting cascade Goussev filtered map is shown in Figure 4, in which magnetic lineaments can be compared to the faults at top of seismic unit V4b interpreted by Hamilton et al. (2001) and to the magnetic lineaments previously reported by Bozzo et al. (1997b).

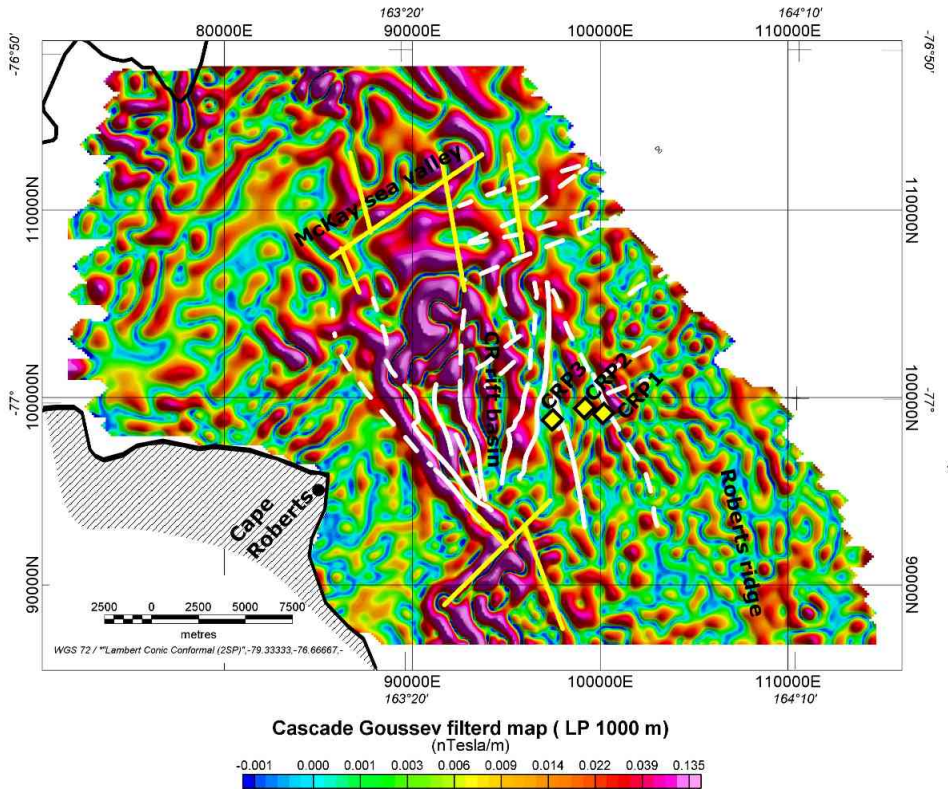


Figure 4. Cascade Goussev filtered magnetic anomaly map. Resulting magnetic lineaments can be compared to the faults (white lines) at top of seismic unit V4b proposed by Hamilton et al. (2001) and to the magnetic lineaments (yellow) previously reported by Bozzo et al., 1997b.

Discussion

When applied to the reduced to the pole draped map, Goussev cascade filtering sharpens magnetic contacts and delineates the boundaries of the CRRB (Figure 4). While these newly-interpreted lineaments generally agree with previous interpretations (Bozzo et al, 1997a; Hamilton, 2001; Figure 5), the new techniques and bathymetry data allow the magnetic signature of the rift basin to be better constrained.

The new lineaments support the high-resolution bathymetry data in defining a basin that appears to be smaller than that which was identified in previous surveys. The western-most lineament mimics the master fault of the McMurdo Fault zone, approximately parallel to the TAM, while the SSW–NNE trending eastern lineaments converge toward an intersection with the NNW–SSE trending eastern bounding fault, with an angle of about 40° between the two trends.

The narrow and steep-sided edged CRRB is filled with sediments that are characterized by low-to-medium amplitude magnetic signatures, even though some high magnetic susceptibility values were recorded in the drill cores. Although the sediments do not generally have high magnetic susceptibilities, a prominent positive magnetic anomaly of about 150 nT, is preserved in low-pass (10 km) filtered maps, suggest the possibility of a deep basin, not previously detected by surveys.

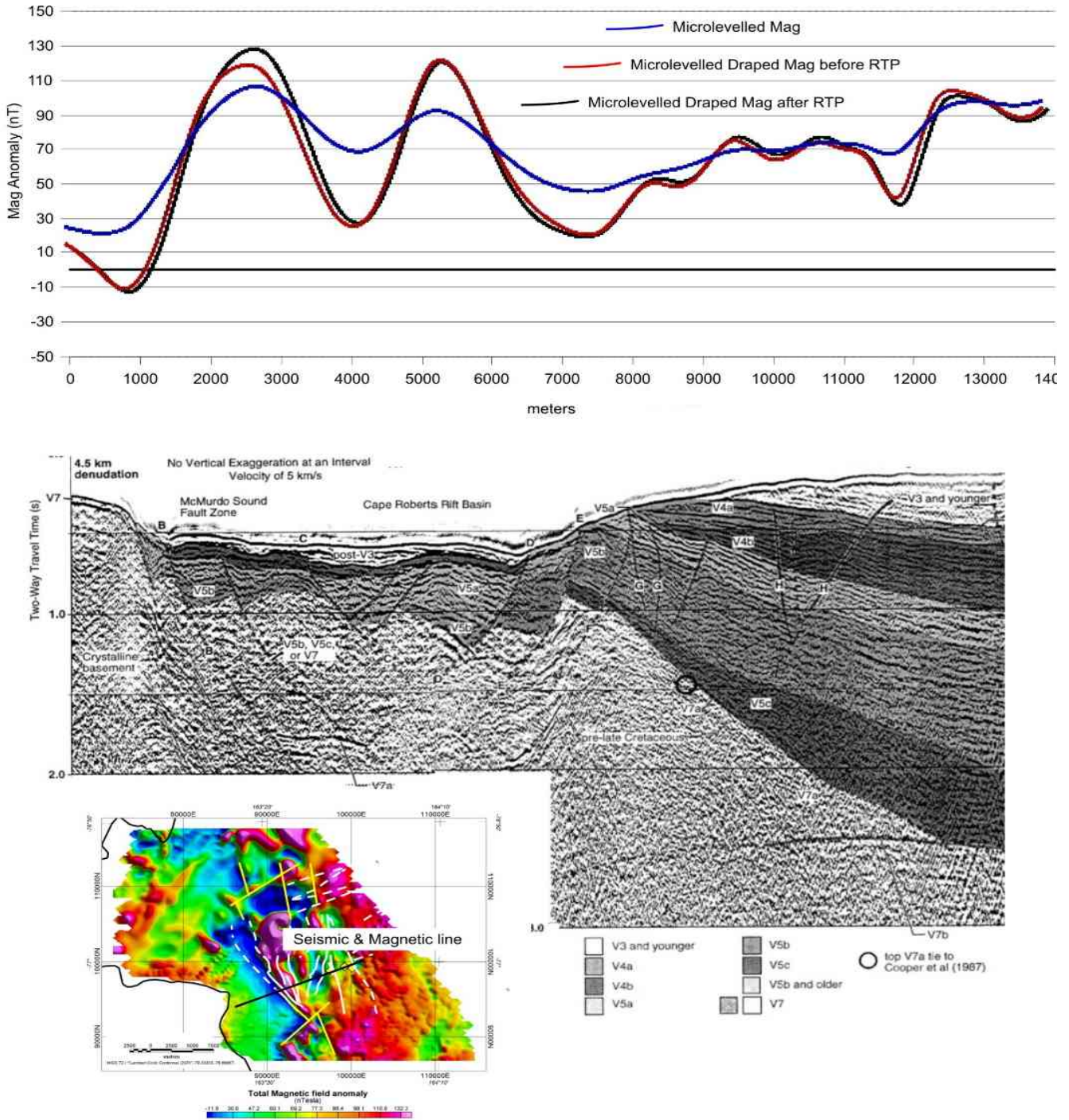


Figure 5. Comparison of magnetic profile (top) and seismic reflection profile (bottom, after Hamilton et al., 2001)

The short wavelength magnetic highs (A, B, C) visible in the reduced to the pole draped map (Figure 3) may be due to intra-sedimentary Cenozoic intrusions, that are also interpreted in seismic data and suggested by the previous magnetic interpretation. The magnetic high 'C' could indicate that magma flows occurred not only on the west flank of CRRB but also on the eastside.

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