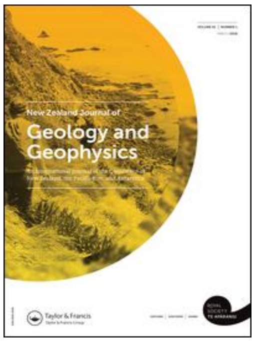

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RESEARCH ARTICLE

Cenozoic continental rifting in the north-western Ross Sea

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ABSTRACT
Marine gravity and seismic data are used to derive a preliminary crustal model for the Central Basin of the northern Ross Sea. The model is consistent with the presence of a thick (8 km) ocean crust. Existing geophysical data indicates the rift forming the Central Basin continues, with offsets, into the Central Trough further south. Using limited existing data on the age (61–53 Ma), and the amount and direction of extension of the Central rift system, an estimate is made of the pole of rotation for 61–53 Ma (79°S, 170°W and rotation 6°). This pole of rotation and those for 43–26 Ma and 26–10 Ma, previously derived, are used to reconstruct the northern Ross Sea margin prior to 61 Ma. The reconstruction shows a close fit of the continental components.

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Ross Sea; Cenozoic rifting; rotation pole; crustal gravity model; continental reconstruction

Introduction

An outstanding problem of western Ross Sea tectonics is the reconstruction of the region prior to extension during the Cenozoic and the role of the Central Basin-Central Trough rifts (Central rift system). The western Ross Sea, part of the Ross Sea-Ross Ice Shelf embayment, lies within the north-western part of the West Antarctic Rift system (Figure 1) and was formed some 180 m.y. ago during the break-up of Gondwana that led to the extension and thinning of West Antarctica (Behrendt et al. 1993). Two main extensional episodes occurred, a regional thinning associated with the break-up of New Zealand and Australia from Antarctica in the Cretaceous, and more focussed extensional episodes, generally north trending rifting, during the Cenozoic (Cooper and Davey 1985). A complex pattern of extensional and oblique motions between East and West Antarctica during the Cretaceous and Cenozoic gave rise to deep sedimentary basins under the Ross Sea and uplift of the Transantarctic Mountains that form the western rift margin of the Ross Sea (e.g. Cooper et al. 1987; Behrendt et al. 1991; Fitzgerald 2005; Wilson and Luyendyk 2009). Recent estimates of the total extension across the region are about 500 km (Wilson and Luyendyk 2009).

Within the western Ross Sea, regional seismic reflection data (Brancolini et al. 1995) have delineated four major rift basins, that form two approximately north-south trending rifts (Figure 2). To the west, in the southwest of the Ross Sea is the Victoria Land Basin that lies along the eastern margin of the Transantarctic Mountains. North of this rift basin and offset to the east is the Northern Basin. To the east, the Central Basin lies between the continental shelves of the Hallett Ridge and the Iselin Bank. Gravity and seismic data trace the rift forming the Central Basin southwards and offset to the west onto the continental shelf to continue further south as the Central Trough (Hayes and Davey 1975; Brancolini et al. 1995).

The Cenozoic rift basins

Analysis of Southern Ocean marine magnetic anomalies indicate three Cenozoic extensional episodes between East and West Antarctica at 26–10 Ma (Granot and Dymont 2018), the well-defined oceanic extension forming the Adare Basin from 43 to 26 Ma (Chron 20–28; Cande et al. 2000a; Granot et al. 2013), and the Central Basin rift from 61 to 53 Ma (Chron 27–24; Cande et al. 2000b; Cande and Stock 2004)., Oceanic magnetic data indicates that the pole of rotation for the most recent event (about 26–10 Ma., PRa in Figure 1) gives minor oblique extension, oriented NE-SW (Granot and Dymont 2018). About 10–15 km of extension occurred in the Terror Rift in western Victoria Land Basin (Henrys 2007) and 7 km extension in Adare Basin (Granot and Dymont 2018), but both with a large component of high-angle faulting (Granot et al. 2010). In both regions, the extensional events were continuous in time with, and occurred spatially within, the older (43–26 Ma) rifts and could be considered as the dying stages of the VLB and Adare Basin rifting processes.

The Adare Basin anomalies can be traced into Northern Basin, indicating the same age of formation. (Cande and Stock 2006; Davey et al. 2006; Granot et al.

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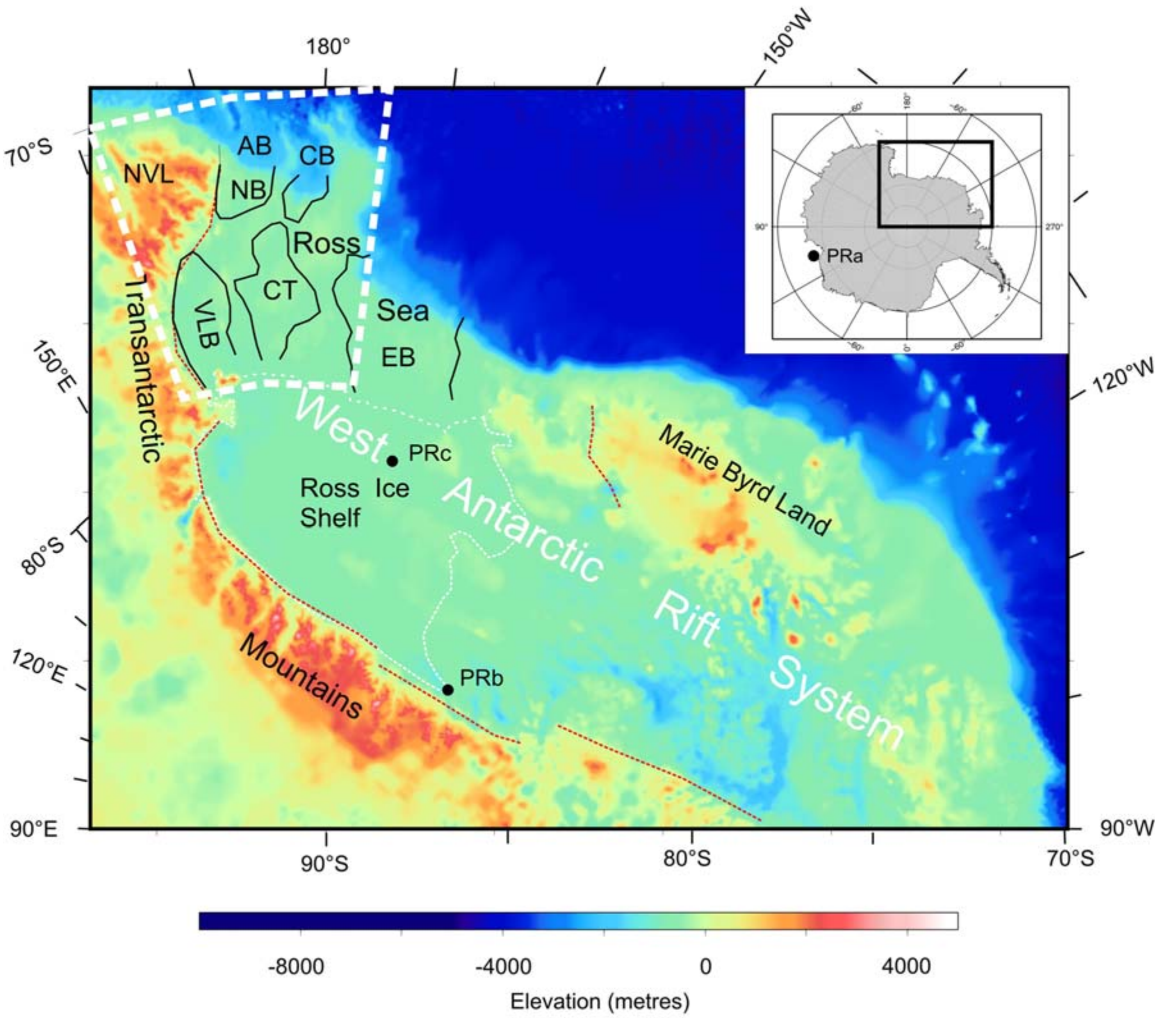

Figure 1. West Antarctic Rift System. Morphology after (Le Brocq et al. 2010). The main Cenozoic sedimentary basins are marked. The white dash box outline shows the extent of Figure 5. AB – Adare Basin, CB – Central Basin, CT – Central Trough, EB – Eastern Basin, NB – Northern Basin, NVL – Northern Victoria Land, VLB – Victoria Land Basin, PRa: 26–10 Ma pole of rotation, PRb: 43–26 Ma pole of rotation, PRc: 61–53 Ma pole of rotation.

2013). The Victoria Land Basin, a major rift basin, is of similar age. Seismic reflection data and geological data from drill core in the basin (CIROS-1; Hannah et al. 1997; Cape Roberts-3; Hamilton et al. 2001) indicate significant sedimentary section below the base of the drill holes indicating an age greater than about 36 Ma for the Victoria Land Basin, consistent with the age of the Northern Basin. The offset between the two basins coincides with a major ENE-WSW magnetic anomaly, the Polar3 anomaly (Figure 2), that has been inferred to correspond to a transfer zone between the two rift basins (Behrendt et al. 1991). It is noteworthy that the rupture of continental crust in Northern Basin was synchronous with the onset of Adare Basin spreading. The tectonics of the Adare Basin, Northern Basin, and Victoria Land Basin has been summarised by Davey et al. (2016) and linked by a pole of rotation for the period (Davey et al. 2006; Granot et al. 2013, PRb in Figure 1).

The earlier rifting episode occurred from 61 to 53 Ma (Chron 27–24; Cande et al. 2000b; Cande and Stock 2004; Wilson and Luyendyk 2009), and formed the Central Basin and Central Trough. Cande and Stock (2004) suggest about 100 km of NE-SW extension occurred. Interpretation of seismic reflection data across the Central Trough is consistent with an early Tertiary age for the oldest sediments there (Decesari et al. 2007a, 2007b). The Central Basin in the north is a major structural and bathymetric feature with water depths in excess of 2000 m and containing over 4000 m of sediments, suggesting that its crust may be oceanic in character (Wilson and Luyendyk 2009). This inference is supported by the continuity of high Bouguer gravity anomalies through to the south of the Central Basin – similar to that over Northern Basin to the west (Figure 3). However, it is poorly defined magnetically with no obvious linear magnetic anomalies within the basin, although the data base is sparse. Geophysical data recorded by USGS S P Lee (SP Lee profile 416–418; Cooper et al. 1987; Davey and Cooper 1987) provide a profile across the central part of the basin (A in Figure 3). Seismic

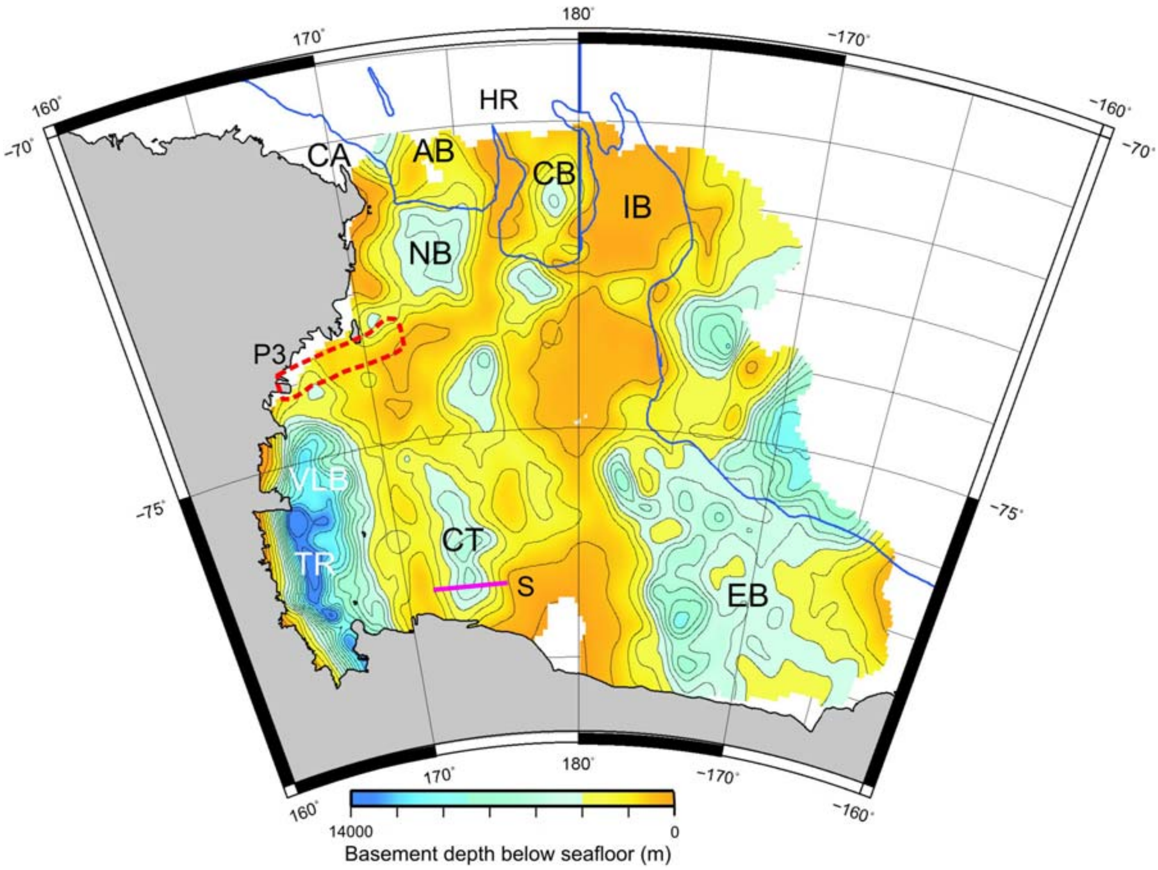

Figure 2. Ross Sea rift basins showing the depth to basement below seafloor (sediment isopachs: Brancolini et al. 1995). CA – Cape Adare, Terror Rift – TR – lies along the western margin of the Victoria Land Basin, Hallett Ridge – HR, Iselin Bank – IB. See Figure 1 for other abbreviations. Red line labelled S – location of Trey et al. 1999 seismic profile across Central Trough. Red dash line labelled P3 – location of the Polar3 magnetic anomaly.

reflection data (Figure 4A) show normal faulted margins to the basin with up to 4300 m of sediments underlying the basin. A basement with seismic velocity of 5.4 km/s at a depth of 6.5 km was measured (Cooper et al. 1987). The measured gravity anomalies along the seismic profile have been used to derive a crustal model for the basin (Figure 4B). Parameters used were: unrifted Ross Sea continental crustal thickness 21 km (after Davey et al. 2016); densities – water 1.03 Mg/m^3, sediment 1.9, 2.25, and 2.6 Mg/m^3, continental basement 2.67 Mg/m^3, lower/oceanic crust 2.9 Mg/m^3, mantle 3.3 Mg/m^3. Relatively steep gravity gradients towards the margins of the deeper part of the basin indicate a thick, steep sided, high density (2.9 Mg/m^3) lower crust, inferred to be oceanic crust, at a similar depth and thickness to that derived for Northern Basin and Adare Basin immediately to the west (Mueller et al. 2005; Davey et al. 2016). The modelled oceanic crust is about 70 km wide. With a total extension of 100 km from oceanic magnetic anomaly analysis (Cande and Stock 2004), this indicates about 30 km of extension associated with continental extension and thinning before rupture.

A rotation pole for extension within the Central rift system can be estimated from the 100 km of NE-SW extension in the Central Basin proposed by Cande and Stock (2004) and an extension estimated from crustal thinning in the Central Trough. Crustal seismic data across the Central Trough shows a crustal thinning from about 23 km to 15 km in the rift graben (Trey et al. 1999) across a rift 100 km wide. This gives a beta factor of 1.7 and a corresponding extension of about 35 km. The degree of strike slip movement along the Central Trough rift is unconstrained. Assuming a modest degree of strike slip in Central Trough and simple NE-SW extension across the northern Central Basin, an approximate pole of rotation of 79°S, 170°W and rotation 6° is estimated (PRa in Figure 1). No formal estimate of uncertainty is given as the input data are not well constrained and the location derived by trial and error.

The uplift of the Transantarctic Mountains may document a fourth rifting episode but the processes causing it are debated and no clear extensional movement has been documented. Although it partially lies along the western margin of the Victoria Land Basin, it lies well to the west of the Northern Basin and thus unrelated to the Adare basin extension. The Transantarctic Mountains were primarily uplifted about 55–50 Ma (Fitzgerald 2005), at the end of the extension episode forming the Central rift system. They lie along a major lithospheric boundary between

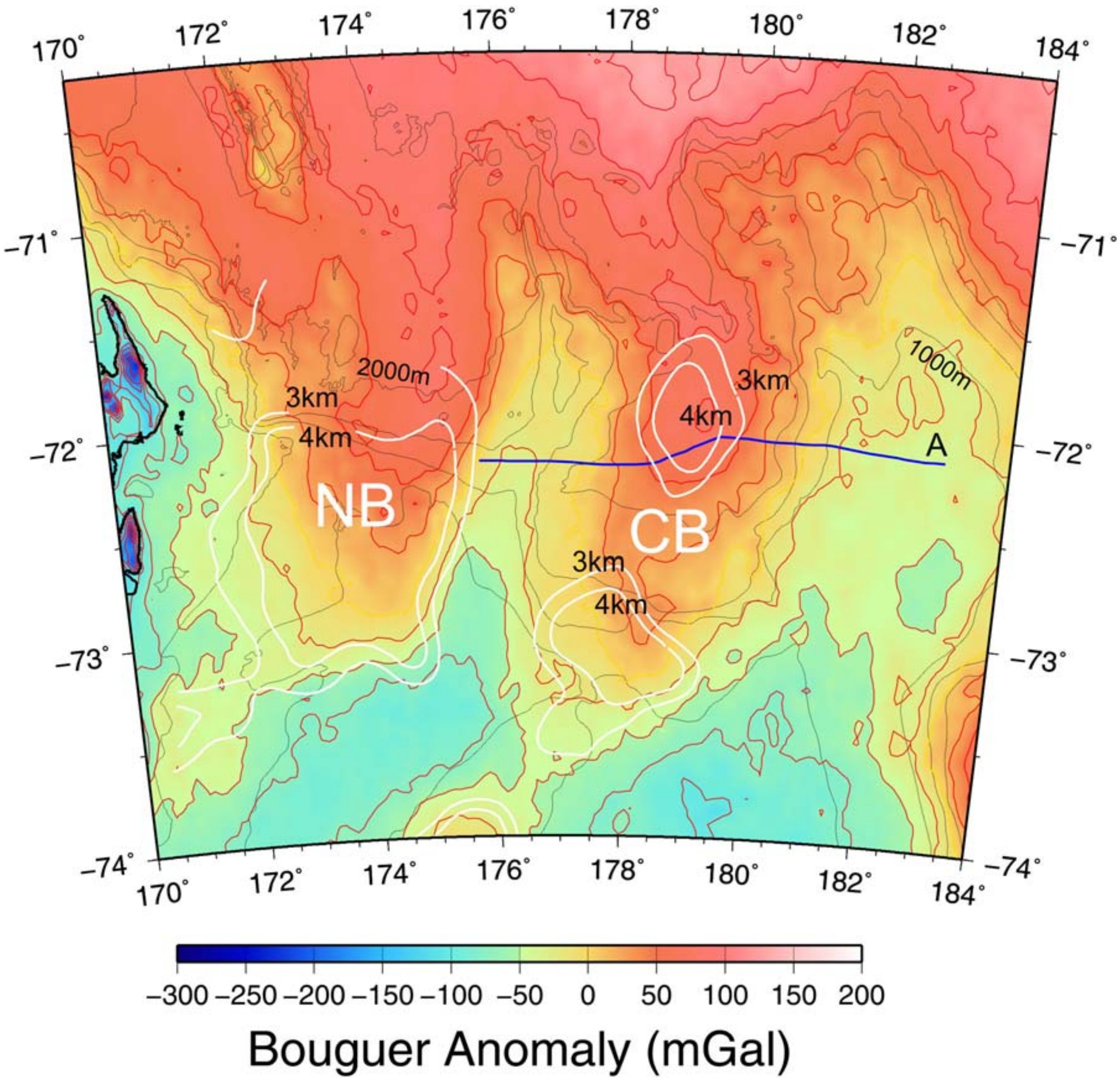

Figure 3. Bouguer anomaly map (modified after Cande and Stock 2006) of Northern Basin, southern Adare Basin and Central Basin showing the continuous high Bouguer anomaly into the Northern Basin (white NB) and Central Basin (white CB). Bouguer anomaly contours – thin red lines, bathymetry contours at 500 m intervals – black lines annotated at 1000 m and 2000m, white lines – sediment isopachs annotated for 3 and 4 km, blue line labelled A – location of profile in Figure 4.

the cold East Antarctica craton and warm mobile West Antarctica (Ritzwoller et al. 2001; An et al. 2015). Speculation as to the cause of the uplift has been extensive but no estimate of any extension occurring there during the Cenozoic has been made.

Reconstruction of the northern Ross Sea margin

The poles of rotation for the Cenozoic rifting noted above are used to reconstruct the continental margin for the northern Ross Sea prior to rifting during the Cenozoic (Figure 5). The margins of continental crust are taken as the present 1500 m isobath. The present 3 and 4 km isopachs are used to show the approximate position of the rift basins under the continental shelf after rotation, with inferred western rift margins shown by red dashed lines in Figure 5. Using the successive poles of rotation the continental margin is rotated back to where it would have been relative to East Antarctica at the onset of each rifting episode (10–26 Ma, 26–43 Ma, 53–61 Ma) Figure 5A, B,C. Reversing the latest rifting event shows that the continental margin for the western Ross Sea was further north relative to the Transantarctic Mountains (Figure 5A) indicating significant right lateral strike slip occurred, consistent with onshore faulting across the western rift boundary (e.g. Wilson 1995).

Prior to the Northern Basin (26–43 Ma) extension, the Hallett Ridge lay along the Cape Adare continental shelf (Figure 5B). The subdued magnetic anomaly over most of the ridge (Cande and Stock 2006) indicates that it is continental. Reversing the 53–61 Ma extension places the Iselin Bank snugly against the Cape Adare/ Hallett Ridge continental shelf edge (Figure 5C). In this Figure only the eastern parts of the isopachs are ahown as the Central rift system is closed and the eastern parts should correspond closely

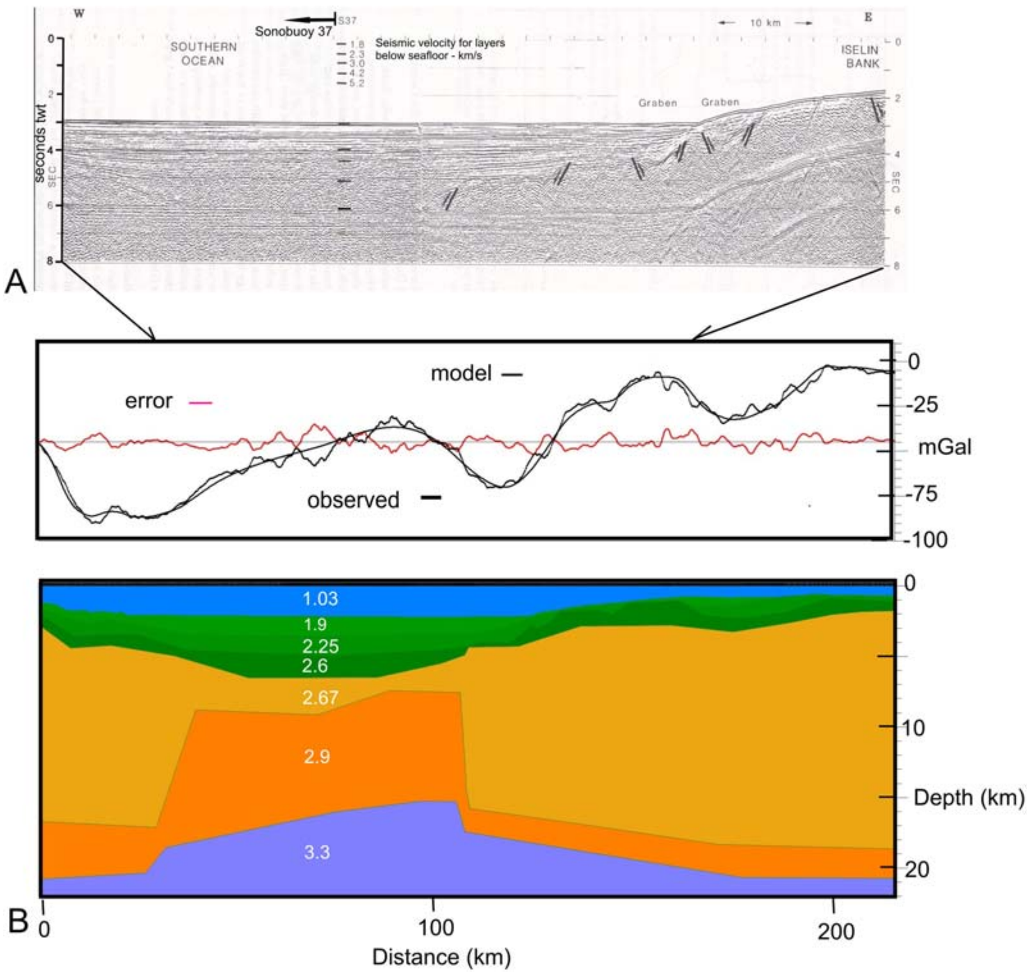

Figure 4. Seismic Profile and Gravity model. **A**, Seismic profile along USGS S P Lee lines 416–418 (Cooper et al. 1987), **B,** Central Basin crustal model along S P Lee lines 416–418. Modelling used Geosoft package. Densities used given in the text and shown on the block model in white. Model rms error is 2.9 mGal.

with the location of the initial rifting (inferred to be where the red dashed lines are in Figure 5). The reconstruction in Figure 5C, however, shows a gap of about 50 km (X in Figure 5C) between the continental shelf edges in the reconstruction at the southwest end of the former Central Basin. Figure 5D shows a more detailed map of this region. Cande and Stock (2004) note that the existence of the Iselin Rift (trending NE from the south end of Iselin Bank – orange bar IR in Figure 5C relative to the 61 Ma shelf edge) and a 12° c.c.w rotation of the Iselin Bank as a separate 'plate' around a pole at its southern end, over the period of the formation of magnetic anomalies 27 to 24.

Simply reversing this rotation (arrow A, Figure 5D) extends to the north the large gap (X Figure 5C) between the continental margins of Adare/Hallett and western margin of Iselin Bank (light green line in Figure 5D) unless the bank was originally further west. Reversing this rotation and allowing a right-lateral transcurrent movement of the Iselin Bank (arrows B and C in Figure 5D) during this period – approximately along the line of the Iselin Rift – enables the continental fragments to reassemble closely (Figure 5D). The pre 61 Ma continental edge would follow the present continental edge north of Iselin Bank (black dash line in Figure 5D), the eastern margin of the final Iselin Bank location in Figure 5D, and then a connection to the 61 Ma continental margin south of Iselin Bank (dashed black line in lower part of Figure 5D). Closing the small graben at the north end of Iselin Bank would give a smoother continental margin but no constraints are available. There is still, however, a small overlap of the western side of Iselin Bank and the Hallett Ridge – Y in Figure 5D. The rotation of the Iselin Bank and the extension forming the Central Basin are inferred to have occurred at the same time (Cande and Stock 2004). This may explain the lack of identifiable ocean magnetic anomalies within the Central Basin, as spreading was very slow and possibly fan-shaped and irregular due to concurrent rotation of the Iselin Bank.

This inferred transcurrent fault zone or transfer zone (grey dashed line, Figure 5D) is co-linear with a major offset and narrowing of the Central rift system – from Central Basin to Central Trough – and with the inferred transfer zone associated with the Polar3 magnetic anomaly and offsetting of Northern

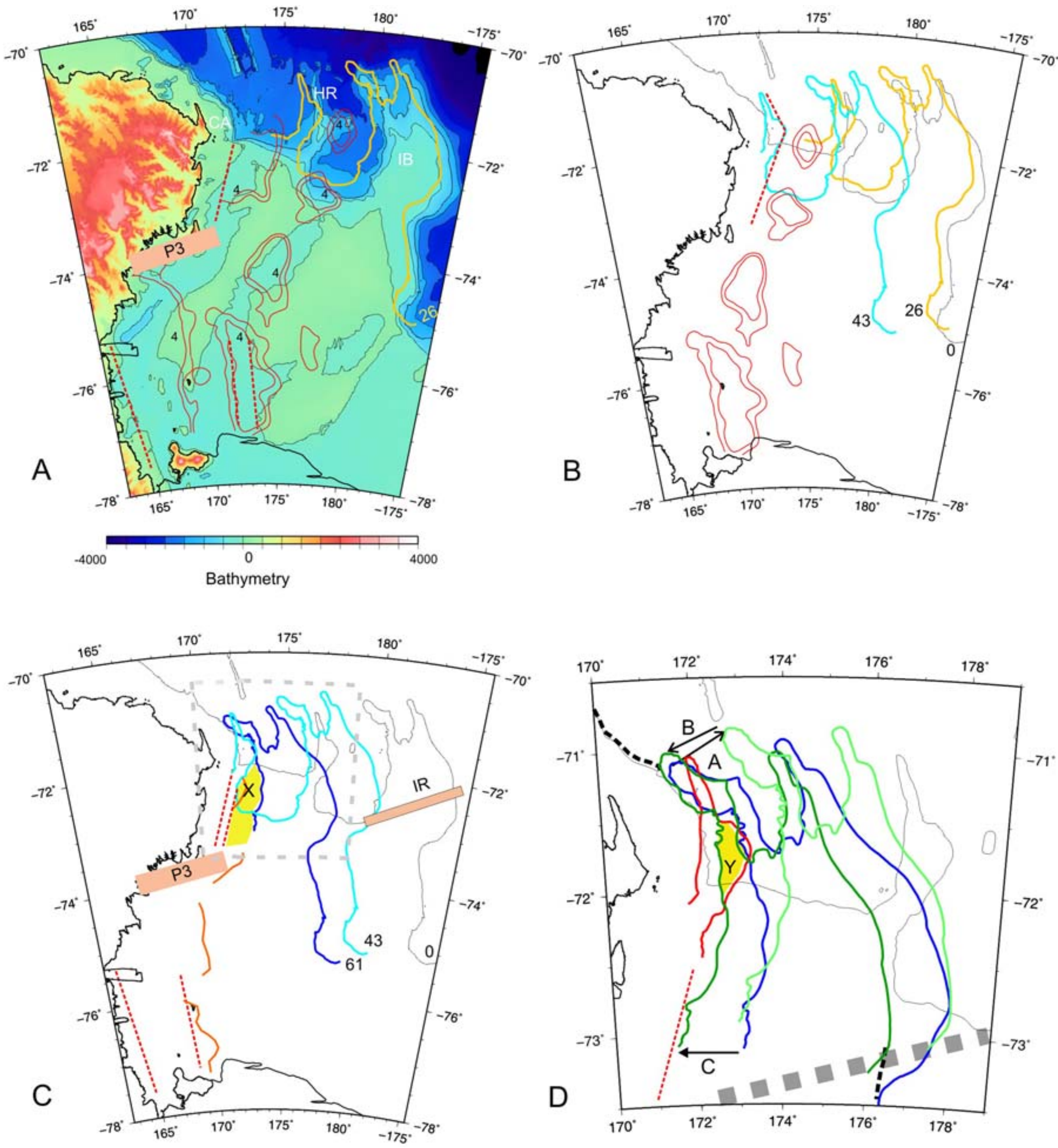

Figure 5. Reconstructed pre-Cenozoic West Ross Sea (4 parts). Bathymetry after Davey (2004). Continental margin (1500 m isobath) at 0 Ma – thin black line; at 26 Ma – yellow line; at 43 Ma – light blue line; at 61 Ma – blue line; at 61 Ma and Iselin Bank rotated – light green line; at 61 Ma and Iselin Bank rotated and translated – dark green line. Red dashed lines – western rift margins, red solid lines – location of present 3 and 4 km isopachs after rotation. **A,** 26 Ma margin overlying present colour-coded bathymetry. Orange bar labelled P3 – Polar3 magnetic anomaly, CA – Cape Adare, HR – Hallett Ridge, IB – Iselin Bank. **B,** 43 Ma continental margin. red solid lines – location of isopachs rotated to 43 Ma. **C,** 61 Ma continental margin, red solid lines – location of isopachs rotated to 61 Ma, Orange bars labelled IR – Iselin Rift, and P3 – Polar3 magnetic anomaly. Red dashed lines – western rift margins for 43 and 61 Ma rifts. Light grey dashed box – area of Figure 4D. X (yellow shading) marks the gap between Iselin Bank and Hallett Ridge continental margins. **D,** detail of continental margin location at 61Ma with and without rotation of Iselin Bank and after west translation along the proposed transfer zone. Initial continental margin (>61 Ma) marked by heavy black dash lines and eastern side of Iselin Bank. Arrow A – movement of north end of Iselin Bank due to the local rotation of the bank. Arrows B and C – west movement of the Iselin Bank along the proposed Iselin Rift – Polar3 transfer zone (grey dashed line). Hallett Ridge delineated by red line. Y (yellow shading) marks a residual continental overlap.

Basin from Victoria Land Basin. The transfer zone appears to be a major tectonic feature marking the southern extent of oceanic crust rift formation both for the Northern Basin and Central Basin and suggesting it may have had a strong influence on continental rifting within the western Ross Sea, perhaps reflecting a change in lithospheric strength from north to south. In the west, the Northern Basin rift continues southwards from oceanic Adare Basin to the transfer zone where rift focus moves to the west for the Victoria Land Basin and Terror Rift to lie along the eastern margin of the Transantarctic Mountains, presumably following a weaker zone in the lithosphere. Whether the transfer zone relates to any of the older major strike slip faults of Northern Victoria Land is unknown.

Conclusions

Geophysical data over the Central Basin are consistent with the basin being underlain by ocean crust about 8 km thick. Assuming that the Central Trough and Central Basin were formed by the same extension episode, a pole of rotation of −79.5°S, 170°Wand rotation 6° is derived. However, it is not well constrained laterally as the degree of strike slip movement during rifting is not known. Using these rotation poles, the pre-rifting position of the Iselin Bank and Hallett Ridge lie snugly against the Cape Adare continental margin after allowing for a counter-clockwise rotation of Iselin Bank and a 50 km eastwards movement along an approximately east-northeast – west-southwest transfer zone or a transcurrent fault zone. This proposed transfer zone runs from the Polar3 anomaly in the west to the Iselin Rift in the east and separates the two major rifts into north and south sections and separates Iselin Bank from the continental shelf to the south. Although both major rifting episodes have some degree of right lateral strike slip motion, that for the Central rift system is very poorly constrained.

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No potential conflict of interest was reported by the author (s).

Data availability statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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References

An M, Wiens DA, Zhao Y, Feng A, Nyblade A, Kanao M, Li Y, Maggi A, Lévêque J-J. 2015. S-velocity model and inferred Moho topography beneath the Antarctic plate from Rayleigh waves. J. Geophys. Res. Solid Earth. 120:359–383. doi:10.1002/2014JB011332.

Behrendt JC, Damaske D, Fritsch J. 1993. Geophysical characteristics of the West Antarctic rift system. Geol. Jahrb. Reihe E. 47:49–101.

Behrendt JC, LeMasurier WI, Cooper AK, Tessensohn F, Trehu A, Damaske D. 1991. Geophysical studies of the West Antarctic rift system. Tectonics. 10:1257–1273.

Brancolini G, Busetti M, Marchetti A, De Santis L, Zanolla C, Cooper AK, Cochrane GR, Zayatz I, Belyaev V, Knyazev M, Vinnikovskaya O, Davey FJ, Hinz K. 1995. Descriptive text for the seismic stratigraphic Atlas of the Ross Sea, Antarctica. In: A. K. Cooper, P. F. Barker, G. Brancolini, editors. Geology and seismic stratigraphy of the Antarctic margin, Antarctic research series, vol. 68. Washington, DC: AGU; p. A271–A287.

Cande SC, Stock JM. 2004. Constraints on the late Cretaceous and Cenozoic extension in the Ross Sea from Southwest Pacific Plate Circuit, Abstract, AGU 2004 Fall meeting, T14A-03, AGU, Washington.

Cande SC, Stock JM, et al. 2006. Constraints on the timing of extension in the Northern Basin, Ross Sea. In: D. Futterer, editor. Antarctica: contributions to global earth sciences. New York: Springer; p. 319–326.

Cande SC, Stock JM, Müller D, Ishihara T. 2000a. Cenozoic motion between East and West Antarctica. Nature. 404:145–150.

Cande SC, Stock JM, Müller D, Ishihara T. 2000b. Two stages of Cenozoic separation in the Western Ross Sea Embayment, Abstract, AGU 2000 Fall Meeting, T62B-20, AGU, Washington.

Cooper AK, Davey FJ. 1985. Episodic rifting of phanerozoic rocks in the Victoria Land Basin; Western Ross Sea, Antarctica. Science. 229:1085–1087.

Cooper AK, Davey FJ, Cochrane GR. 1987. Structure of extensionally rifted crust beneath the Western Ross Sea and Iselin Bank, Antarctica, from Sonobuoy seismic data. In: Cooper A.K., Davey F.J, editor. The Antarctic continental margin: geology and geophysics of the Western Ross Sea, vol. 5B. Houston, TX: Circum-Pacific Council for Energy and Mineral Resources, Earth Science Series; p. 93–118.

Davey FJ. 2004. Ross sea bathymetry, 1:200,000. Geophysical map, Institute of Geological & Nuclear Sciences 16, Institute of Geological & Nuclear Sciences Limited.

Davey FJ, Cande SC, Stock JM. 2006. Extension in the western Ross Sea region-links between Adare Basin and Victoria Land Basin. Geophysical Research Letters. 33: L20315. doi:10.1029/2006GL027383.

Davey FJ, Cooper AK. 1987. Gravity studies of the Victoria Land Basin and Iselin bank. In: Cooper A.K., Davey F.J, editor. The Antarctic continental margin: geology and geophysics of the Western Ross Sea, vol. 5B. Houston, TX: Circum-Pacific Council for Energy and Mineral Resources, Earth Science Series; p. 119–138.

Davey FJ, Granot R, Cande SC, Stock JM, Selvans M, Ferraccioli F. 2016. Synchronous oceanic spreading and continental rifting in West Antarctica. Geophys. Res. Lett. 43. doi:10.1002/2016GL069087.

Decesari RC, Sorlien CC, Luyendyk BP, Wilson DS, Bartek L, Diebold J, Hopkins SE. 2007b. Regional seismic stratigraphic correlations of the Ross Sea: implications for the tectonic history of the West Antarctic Rift System. In: AK Cooper et al., editors. Antarctica: A Keystone in a Changing World – Online Proceedings of the 10th ISAES X, U.S. Geol. Surv. Open File Rep., 2007–1047, Short Research Paper 052, 6p. doi:10.3133/of2007-1047.srp052.

Decesari RC, Wilson DS, Luyendyk BP, Faulkner M. 2007a. Cretaceous and tertiary extension throughout the Ross Sea, Antarctica. In: AK Cooper et al., editors. Antarctica: A Keystone in a Changing World – Online

Proceedings of the 10th ISAES X, U.S. Geol. Surv. Open File Rep., 2007–1047, Short Research Paper 098, 6p. doi:10.3133/of2007-1047.srp098.

Fitzgerald PG. 2005. Tectonics and landscape evolution of the Antarctic plate since Gondwana breakup, with an emphasis on the West Antarctic rift system and the Transantarctic Mountains. In: JA Gamble et al., editors. Antarctica at the close of a Millennium, Proceedings of the 8th International Symposium on Antarctic Earth Science. Royal Society of New Zealand; p. 453–469.

Granot R, Cande SC, Stock JM, Damaske D. 2013. Revised Eocene-Oligocene kinematics for the West Antarctic rift system. Geophysical Research Letters. 40. doi:10.1029/2012GL054181.

Granot R, Cande SC, Stock JM, Davey FJ, Clayton RW. 2010. Postspreading rifting in the Adare Basin, Antarctica: regional tectonic consequences. Geochem. Geophys. Geosyst. 11:Q08005. doi:10.1029/2010GC003105.

Granot R, Dymont J. 2018. Late Cenozoic unification of East and West Antarctica. Nature Communications. 9:3189. doi:10.1038/s41467-018-05270-w.

Hamilton RJ, Luyendyk BP, Sorlien CC, Bartek LR. 2001. Cenozoic Tectonics of the Cape Roberts rift basin and the transantarctic mountains front, Southwestern Ross Sea, Antarctica. Tectonics. 20:325–342.

Hannah MJ, Cita MB, Coccione R, Monechi S. 1997. The Eocene/Oligocene boundary at 70° south, McMurdo sound, Antarctica. Terra Antarctica. 4(2):79–87.

Hayes DE, Davey FJ. 1975. A geophysical study of the Ross Sea, Antarctica. Initial Reports of the Deep Sea Drilling Project. 28:887–908.

Henrys S, et al. 2007. Future Antarctic geological drilling: discussion paper on ANDRILL and beyond, Paper 049. Antarctica: a keystone in a changing world. In: Cooper et al., editors. Online Proceedings of the 10th ISAES. USGS.

Le Brocq AM, Payne AJ, Vieli A. 2010. Antarctic dataset in netCDF format. doi:10.1594/PANGAEA.734145.

Mueller RD, Cande SC, Stock JM, Keller WR. 2005. Crustal structure and rift flank uplift of the Adare trough, Antarctica. Geochem. Geophys. Geosyst. 6:Q11010. doi:10.1029/2005GC001027.

Ritzwoller MH, Shapiro NM, Levshin AL, Leahy GM. 2001. The structure of the crust and upper mantle beneath Antarctica and the surrounding oceans. Journal of Geophysical Research. 106:30645–30670.

Trey H, Cooper AK, Pellis G, della Vedova B, Cochrane G, Brancolini G, Makris J. 1999. Transect across the West Antarctic rift system in the Ross Sea, Antarctica. Tectonophysics. 301:61–74.

Wilson T. 1995. Cenozoic transtension along the transantarctic mountains-West Antarctic rift boundary, southern Victoria Land, Antarctica. Tectonics. 14:531–545.

Wilson DS, Luyendyk BP. 2009. West Antarctic paleotopography estimated at the Eocene-Oligocene climate transition. Geophysical Research Letters. 36:L16302. doi:10.1029/2009GL039297.