Geophysical Evidence of the Collisional Suture Zone in the Prydz Bay, East Antarctica

Lei Fu[1], Jingxue Guo[2], Weisen Shen[3], Xin Wang[4], Xiaochun Liu[5], Xiaofei Chen[6], Xiangyun Hu[1*]

[1] Hubei Subsurface Multiscale Imaging Key Laboratory, School of Geophysics and Geomatics, China University of Geosciences, Wuhan 430074, China

[2] Key Laboratory for Polar Science, MNR, Polar Research Institute of China, Shanghai 200136, China

[3] Department of Geosciences, Stony Brook University, NY 11794, USA

[4] Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

[5] Institute of Geomechanics, Chinese Academy of Geological Sciences, Beijing 10081, China

[6] Department of Earth and Space Sciences, Southern University of Science and Technology, Shenzhen 518055, China

* Corresponding author: Xiangyun Hu (xyhu@cug.edu.cn)

Key Points:

- A distinct Moho discontinuity offset of 6-8 km is founded in the stacked image obtained from P-wave receiver function;
- In conjunction with the abrupt Moho offset, a nearly vertical conduit with low resistivity and high Poisson's ratio is identified;
- These geophysical results provide crucial evidence for determining the collisional nature and location of the Prydz orogenic belt.

Abstract

The location and origin of Neoproterozoic-Cambrian sutures provide keys to understand the formation and evolution of the supercontinent Gondwana. The Larsemann Hills is located near a major Neoproterozoic-Cambrian suture zone in the Prydz Belt, but has not been examined locally by comprehensive geophysical studies. In this study, we analyzed data collected from a 1-D joint seismic-MT array deployed during the 36th Chinese National Antarctic Research Expedition. We found that a sharp Moho discontinuity offset of 6-8 km shows up in the stacked image of teleseismic P-wave receiver function analysis; coinciding with the abrupt Moho offset, a near-vertical channel with (1) low resistivity extending to the uppermost mantle depths, and (2) a high crustal Poisson's ratio in the crust is identified. These findings provide evidence for the determination of the location and collisional nature of the Prydz belt or a portion of it.

Plain Language Summary

Our study focuses on understanding the formation of the supercontinent Gondwana by investigating ancient geological features called Neoproterozoic-Cambrian sutures. We specifically examined the Larsemann Hills region near a significant suture zone in Antarctica, a location that hasn't received much attention in terms of geophysical research until now. Using data collected during the 36th Chinese National Antarctic Research Expedition, we made exciting discoveries. We identified a sharp disruption in the Earth's crust called the Moho discontinuity. Simultaneously, we found a vertical channel with unique characteristics: it had low electrical resistance, suggesting distinct rock properties reaching deep into the Earth's mantle, and a high Poisson's ratio in the crust. These findings strongly suggest a connection between these geophysical anomalies and the ancient sutures in the Earth's crust.

1. Introduction

The Prydz tectonic zone, known as the Prydz Belt (Figure 1a), is situated in East Antarctica near the Prydz Bay-Prince Charles Mountains area. This region is characterized by the convergence of three prominent Precambrian cratons, namely East Antarctica, Africa, and Australia (Fitzsimons, 2000b). The geological imprints of tectonic evolution during the Neoproterozoic-Early Paleozoic period have been preserved in this area, making the Prydz Bay area pivotal for understanding the formation and evolution of the supercontinent Gondwana (Boger et al., 2001; Harley, 2003; Mikhalsky et al., 2006; Tingey, 1991). It is widely accepted that this region represents a Proterozoic continental suture, potentially connected to the Darling orogenic belt in Western Australia towards the northeast, with potential extensions to the northern margin of the Indian plate (Fitzsimons, 2000a). Geographically, the suture may extend further to the Prince Charles Mountain, Dronning Maud Land, and the Gamburtsev Subglacial Mountains (Fitzsimons, 2003) (Figure 1b). Gupta et al. (2021) proposed the Indo-Antarctica suture (Figure 1a) coincides with the Pan-African Kuunga suture (Arora et al., 2020; Boger et al., 2001), which connects the southern Prince Charles Mountain with coastal outcrops of Prydz Bay through the Grove Mountains (Xiaohan Liu et al., 2003), and represents the easternmost boundary of the Kuunga Orogen. However, these hypothesis have not been fully examined by Geophysical investigations, which play a crucial role in understanding the origins of continental suture zones (Burtman & Molnar, 1993). These investigations can directly detect the presence of high-grade metamorphic sedimentary rocks generated by the subduction of oceanic plates, manifesting as anomalous seismic, resistivity, and magnetic readings (Von Huene & Scholl, 1991). Moreover, seismic discontinuities often serve as indicators of deformation resulting from tectonic events (Katsumata, 2010). Notably, significant deformation, such as large-scale strike-slip faults, can intersect Moho discontinuities, thus being identifiable through seismic investigations (McBride, 1994). Crustal deformation associated with orogeny and extension induces cracks, compositional changes, and fluid presence, all of which influence the Poisson's ratio (Lowry & Pérez-Gussinyé, 2011). These effects can be detected using converted phases of remote seismic events.

Despite advancements, geophysical investigations of the Prince Charles Mountain area have faced challenges due to sparse observations, hindering a comprehensive understanding of the belt's origins. For instance, previous receiver function investigations in the Lambert Glacier region were conducted at scattered stations across the Prydz Belt, limiting the resolution needed to precisely identify the location of suture zones (Reading, 2006). A recent study constructed a 3D resistivity model using Magnetotellurics (MT) data, which identified low electrical conductivity and magnetic high-intensity between the Vestfold Hills and Rauer Group, interpreted as a continental suture zone (Peacock & Selway, 2016). However, these studies have not presented a unified model that definitively supports either of the Prydz Belt's origination models. Consequently, geophysical signatures related to the origin of the Prydz Belt remain inadequately investigated. This study presents the first comprehensive in-situ geophysical observations within the central Prydz Belt zone by deploying a local 1-D seismic and MT array in the geologically significant Larsemann Hills during the 36th Chinese National Antarctic Research Expedition (CHINARE36). The Larsemann Hills, being an important site for geologists and geophysicists studying the Prydz Belt, have the potential to preserve structural signatures (e.g., deep crustal compositional anomalies (Tarney & Jones, 1994) or discontinuity anomalies (Dong et al., 2004) related to orogenic development. Therefore, investigating the subsurface structure in this region provides valuable insights into the tectonic environment of the

Prydz Belt and the formation of Gondwana.

The analysis of seismic and MT data reveals several key observations. Firstly, a distinct Moho discontinuity is identified, delineating a suture zone that coincides with the previously perceived Proterozoic tectonic belt. Secondly, the deep crust within the suture zone exhibits higher Poisson's ratio, anomalously low resistivity, and elevated magnetic anomaly. These signatures suggest the presence of a deep crustal compositional anomaly, such as high-grade metamorphic sedimentary materials (e.g., graphite, as suggested by Cost et al., 1968), likely transported from the surface to the lower crust. These geophysical observations strongly indicate a subduction origin for the Prydz Belt or a portion of it. Collectively, these findings support the hypothesis that the Prydz Belt represents a continental suture zone with a subduction-related origin.

2. Data and Results

2.1 Seismic and MT Data

An ultra-dense short-period nodal seismic array consisting of 100 seismic stations was deployed in the Larsemann Hills, with an average station spacing of 200 m (depicted as brown triangles in Figure 1c). Notably, the seismic profile deviated eastward near station MT08 to circumvent ice cracks. Due to limitations imposed by the nodal station batteries, seismic recording was conducted from December 5, 2019, to January 3, 2020, resulting in a record duration of approximately 30 days. In this study, we employed a recently developed array-based technique called Coherent Receiver Function (CRF) imaging, operating within the Bayesian framework (Wang et al., 2021). This approach effectively capitalizes on the ultra-dense yet short-duration nodal array, enabling the generation of high-resolution subsurface structure images (see

Supplementary Information for the CRF Method). Additionally, broadband (0.003125-1000 s) Magnetotelluric (MT) data were collected at 10 sites (indicated by yellow triangles in Figure 1c) within the same seismic deployment. The recording durations for the MT measurements ranged from three days to one week. The average spacing between MT stations was approximately 2-3 km, resulting in an MT observation aperture of approximately 26 km.

2.2 Seismic Structure

Seismic analysis of the Larsemann Hills seismic data yielded three seismic products: crustal Poisson's ratio, stacked Coherent Receiver Function (CRF) image, and shallow seismic velocities, shown in Figure 2a, 2b and 2c, respectively. The stacked CRF results, generated from four earthquakes with magnitudes greater than 5.8 (indicated by purple circles in Figure S1), are presented in Figures 2b. A prominent positive P-s conversion is clearly observed at a depth of approximately 30 km, signifying the presence of a sharp Moho discontinuity. At a distance of approximately 5-10 km from the northern end of the seismic array, a sudden Moho offset of approximately 6-8 km is observed, dividing the study area into northern and southern blocks. The average depths of the Moho in the northern and southern blocks are estimated to be around 30-32 km and 34-36 km, respectively. The CRF analysis, accompanied by Bayesian uncertainty assessment, demonstrates a robust observation of the abrupt Moho change, with the Moho signals imaged at a confidence level of 68% or higher (Figure S3). This observation highlights a significant alteration in geophysical properties within the deep crust, likely resulting from large-scale tectonic activity in the region. Furthermore, the average Poisson's ratio for the Moho-disturbed region is approximately 0.28, whereas the average Poisson's ratios for the northern and southern blocks are approximately 0.25 and 0.26, respectively. The Poisson's ratio in the Moho-disturbed region is notably higher than that in the adjacent blocks. In addition, a low shear wave velocity (Vs) in the uppermost 2 km is observed in Figure 2c, which may be related to granite intrusions or rock fragmentation.

2.3 Resistivity Model

The 2D electrical resistivity model (Figures 2d) presented herein is obtained through inversion using the non-linear conjugate gradient method (Newman & Alumbaugh, 2000). The predicted apparent resistivity and phase derived from the resulting preferred resistivity model exhibit excellent agreement with the observed data (Figure S4). The preferred model reveals three distinct layers extending from the surface to a depth of approximately 60 km within the uppermost mantle. The first layer corresponds to an upper crust characterized by high resistivity (referred to as R1). The second layer comprises a significant and highly conductive zone spanning depths between 10 and 30 km (referred to as C2). The third layer, located beneath the Moho, exhibits a more intricate electrical structure, consisting of two sub-vertical zones with high resistivity (R2 and R3) and a sub-vertical zone with low resistivity (C3) in the middle. The low-resistivity zone (C3) extends downward into the upper mantle and connects to the conductive zone (C2) in the lower crust, forming a vertically oriented conduit for electrical conductivity.

2.4 Geophysical Interpretation

We interpret the abrupt Moho offset as a crustal-scale high-angle strike-slip faults, named F1 and F2, ~ 5 km separated from each other. The deep fault system indicates a significant structural interface in this region. The high crustal Poisson's ratio between F1 and F2 is either caused by the existence of fluid or cracks, or from the crustal composition (mafic rocks generally have higher Poisson's ratio). Given that the near surface low Vs anomaly (Figure 2c) in the same region, we interpret them (low Vs, high Poisson's ratio) as a signature of wide-spread cracks, a common phenomenon of continental suture zone.

The preferred 2D resistivity model shows that electrical structures also vary across the conduit defined by seismic signature. Off the conduit, the average resistivity to the south is higher than that to the north, indicating different compositional properties of the two crustal bodies. The location of near-vertical low resistivity (less than 10 Ω-m) channel in the lithospheric mantle connecting to lower crust basically overlaps with the abrupt Moho. The relatively high conductivity zone (C3) in the uppermost mantle exhibits a near vertical structure, clearly separating the lithospheric mantle into norther and southern parts. These low conductivity bodies in the crust and uppermost mantle (esp. C2 and C3 shown in Figures 2d), provide some of the direct evidence of compositional alternation to the lithosphere. Generally, high conductivity of deep crust and uppermost mantle is either due to existence of fluids (e.g., existence of melt and water) or due to compositional anomaly (e.g., electron conduction due to sulfide and graphite). Given the Neoproterozoic age of the recent tectonism and low geothermal heat flux (Shen et al., 2020), it is unlikely that melt exists in shallow lithosphere (0-60 km depth). The high conductivity in deep crust is not due to water since the pressure would close the cracks and minimize the porosity of the rocks. Hence, we interpret the extremely high conductivity body (C2) as a compositional origin, most likely due to graphite and sulfide, usually found in a convergent plate boundary (Abdul Azeez et al., 2015).

3. Discussion

Overall, the new geophysical data collected in the Larsemann Hills indicates a continental suture zone at the periphery of the East Antarctica. Evidence such as the deep cutting faults that penetrates through the Moho, as well as the wide-spread cracks within the crust that produces lower Vs and higher Poisson's ratio localized between the faults all support strong crustal deformation, perhaps related to the collapse of an orogeny related to the suturing. The low-resistivity bodies found in the deep crust and uppermost mantle are most likely due to the existence of graphite and sulfide films along the grain boundaries, usually found in metamorphism that is related to lithospheric suturing (Selway, 2014).

Magnetic anomaly map (Golynsky et al., 2018) in the Larsemann Hills, Prydz Bay presents a nearly east-west strip of high magnetic intensity that runs through the southern part of the seismic survey line and corresponds to the high-conductivity anomalies C1-C2 in the resistivity model. The high-magnetic anomalies probably represent the breakdown of magnetite, another suture-related metamorphism signature; and finally, the steep low resistivity channel indicates the channel for the transport of heat that induces the metamorphism. In addition, A SWW trending suture zone was speculated from MT data (Peacock & Selway, 2016) between Rauer Group and Vestfold Hills, which is about 100 km north-east of our study area, Larsemann Hills.

A subduction-induced orogenic belt (Boger et al., 2001) has been proposed based on a clockwise *P-T* evolution trajectory (Kelsey et al., 2003; Liu et al., 2009) of compression, and extensional deformation (Carson et al., 1995) accompanied by isothermal decompression. In addition, the age difference of the Greenville terrane on both sides of the orogenic belt and the inconsistency of the paleomagnetic pole shift curves between India and Australia before the Late Neoproterozoic-Early Paleozoic also support this hypothesis (Torsvik, 2001). The lack of direct indicator of subduction-related facies signs in orogenic belts can be used to support an intraplate orogen (Yoshida et al., 2003). Both collisional models predict a continental suture zone at the edge of the East Antarctica near the Larsemann Hills. Additionally, the low resistivity likely due to graphite at depth up to ~ 60 km is consistent with the subduction-induced collisional model, since subduction is the major mechanism that brings hydrogen and carbon to such a depth (Dasgupta & Hirschmann, 2010).

Therefore, based on the deep geophysical imaging structures and background geology, it is suggested that the Moho disturbed region (5-10 km along the profile) probably represents an ancient subduction-induced suture zone between the Indo-Antarctica and East Antarctica (Zong et al., 2022). A possible scenario of the Pre-Cambrian-Early Proterozoic tectonism in the region can be proposed as follow: during or before the Pan-Africa, the Indo-Antarctic block collided (probably have subducted) with East Gondwana along the southern Prince Charles Mountain-Prydz Bay (Figure 3a).

During the same (or post) subduction, due to the extension and thinning of the originally thickened crust, perhaps driven by the high gravitational potential energy, the mantle-derived magma rose along the lithospheric suture zone (weak zone) to the crust-mantle transition zone and under-intruded into the lower crust (Figure 3b), forming the A-type magma granite near the surface (Zong et al., 2022). The presence of carbon dioxide-rich fluid or reduction of mineral grains caused by local shearing or a combination of both results in the growth of graphite films along the grain boundaries, resulting an increase in electrical conductivity. The same extension generated large-scale high angle normal faults that cut through the crust, and caused massive cracks within the crust. These signatures have been preserved as part of the Gondwana, and the weak suture zones allows the later breakup of the supercontinent, and separates India Plate from Antarctica.

4. Conclusion

Through comprehensive analysis of seismic and Magnetotelluric data within the Larsemann

Hills region, we have uncovered compelling evidence supporting a notable Moho discontinuity offset of 6-8 km. This distinctive feature is prominently displayed in the stacked image derived from teleseismic P-wave receiver function analysis. Concurrently, our investigations have unveiled a nearly vertical conduit exhibiting two key characteristics: (1) a region of low resistivity that extends to uppermost mantle depths and (2) a pronounced high Poisson's ratio within the Earth's crust. These geophysical findings are of paramount importance as they contribute significantly to our understanding of the Prydz orogenic belt, shedding light on its collisional nature and precise location. Building upon the contextual framework of geological knowledge, we propose that the region exhibiting disturbance in the Moho is indicative of an ancient subduction-induced suture zone. This geological feature likely represents a historically significant boundary between the Indo-Antarctica and East Antarctica continental masses.

Acknowledgments

We thank Zhanxiang He (Southern University of Science and Technology), Dr. Feng Jiang (South China Sea Institute of Oceanology, Chinese Academy of Sciences) and Cuixian Meng (BGP Inc., China National Petroleum Corporation) for help in the MT data analysis. This work was supported by the “CUG Scholar” Scientific Research Funds at China University of Geosciences (Wuhan) (Project No.2022132) and National Natural Science Foundation of China (Grant No. 41974044).

Open Research

All data needed to evaluate the conclusions in the paper are available from the HARVARD dataverse (https://doi.org/10.7910/DVN/GQXVND).

References

Abdul Azeez, K. K., Veeraswamy, K., Gupta, A. K., Babu, N., Chandrapuri, S., & Harinarayana, T. (2015). The electrical resistivity structure of lithosphere across the Dharwar craton nucleus and Coorg block of South Indian shield: Evidence of collision and modified and preserved lithosphere. *Journal of Geophysical Research: Solid Earth*, *120*(10), 6698–6721. https://doi.org/10.1002/2014JB011854

Arora, D., Pant, N., Pandey, M., Chattopadhyay, A., Greenbaum, J., Siegert, M., et al. (2020). Insights into geological evolution of Princess Elizabeth Land, East Antarctica-clues for continental suturing and breakup since Rodinian time. *Gondwana Research*, *84*, 260–283. https://doi.org/10.1016/j.gr.2020.05.002

Boger, S. D., & Wilson, C. J. L. (2005). Early Cambrian crustal shortening and a clockwise P–T–t path from the southern Prince Charles Mountains, East Antarctica: implications for the formation of Gondwana. *Journal of Metamorphic Geology*, *23*(7), 603–623. https://doi.org/10.1111/j.1525-1314.2005.00598.x

Boger, S. D., Wilson, C. J. L., & Fanning, C. M. (2001). Early Paleozoic tectonism within the East Antarctic craton: The final suture between east and west Gondwana? *Geology*, *29*(5), 463. https://doi.org/10.1130/0091-7613(2001)029<0463:EPTWTE>2.0.CO;2

Burtman, V. S., & Molnar, P. (1993). Geological and geophysical evidence for deep subduction of continental crust beneath the Pamir.

Carson, C. J., Dirks, P. G. H. M., Hand, M., Sims, J. P., & Wilson, C. J. L. (1995). Compressional and extensional tectonics in low-medium pressure granulites from the Larsemann Hills, East Antarctica. *Geological Magazine*, *132*(2), 151–170.

https://doi.org/10.1017/S0016756800011729

Cost, J. R., Janowski, K. R., & Rossi, R. C. (1968). Elastic properties of isotropic graphite. *The Philosophical Magazine: A Journal of Theoretical Experimental and Applied Physics*, *17*(148), 851–854. https://doi.org/10.1080/14786436808223035

Dasgupta, R., & Hirschmann, M. M. (2010). The deep carbon cycle and melting in Earth's interior. *Earth and Planetary Science Letters*, *298*(1–2), 1–13. https://doi.org/10.1016/j.epsl.2010.06.039

Dong, S., Gao, R., Cong, B., Zhao, Z., Liu, X., Li, S., et al. (2004). Crustal structure of the southern Dabie ultrahigh-pressure orogen and Yangtze foreland from deep seismic reflection profiling. *Terra Nova*, *16*(6), 319–324.

Fitzsimons, I. C. W. (2000a). A review of tectonic events in the East Antarctic Shield and their implications for Gondwana and earlier supercontinents. *Journal of African Earth Sciences*, *31*(1), 3–23. https://doi.org/10.1016/S0899-5362(00)00069-5

Fitzsimons, I. C. W. (2000b). Grenville-age basement provinces in East Antarctica: Evidence for three separate collisional orogens, 4.

Fitzsimons, I. C. W. (2003). Proterozoic basement provinces of southern and southwestern Australia, and their correlation with Antarctica. In M. Yoshida, B. F. Windley, & S. Dasgupta (Eds.), *Proterozoic East Gondwana: Supercontinent Assembly and Breakup* (Vol. 206, p. 0). Geological Society of London. https://doi.org/10.1144/GSL.SP.2003.206.01.07

Golynsky, A. V., Ferraccioli, F., Hong, J. K., Golynsky, D. A., von Frese, R. R. B., Young, D. A., et al. (2018). New Magnetic Anomaly Map of the Antarctic. *Geophysical Research Letters*, *45*(13), 6437–6449. https://doi.org/10.1029/2018GL078153

Gupta, S., Chatterjee, S., Arora, D., Bose, S., & Dobe, R. (2021). Locating the Indo-Antarctica suture – Correlating the Rengali, Rauer and Ruker terranes in Gondwana. *Polar Science*, *30*, 100689. https://doi.org/10.1016/j.polar.2021.100689

Harley, S. (2003). Archaean-Cambrian crustal development of East Antarctica: metamorphic characteristics and tectonic implications. *Geological Society, London, Special Publications*, *206*(1), 203–230.

Katsumata, A. (2010). Depth of the Moho discontinuity beneath the Japanese islands estimated by traveltime analysis. *Journal of Geophysical Research*, *115*(B4), B04303. https://doi.org/10.1029/2008JB005864

Kelsey, D. E., White, R. W., Powell, R., Wilson, C. J. L., & Quinn, C. D. (2003). New constraints on metamorphism in the Rauer Group, Prydz Bay, east Antarctica. *Journal of Metamorphic Geology*, *21*(8), 739–759. https://doi.org/10.1046/j.1525-1314.2003.00476.x

Kelsey, D. E., Wade, B. P., Collins, A. S., Hand, M., Sealing, C. R., & Netting, A. (2008). Discovery of a Neoproterozoic basin in the Prydz belt in East Antarctica and its implications for Gondwana assembly and ultrahigh temperature metamorphism. *Precambrian Research*, *161*(3–4), 355–388. https://doi.org/10.1016/j.precamres.2007.09.003

Liu, Xiaochun, Jahn, B.-M., Zhao, Y., Zhao, G., & Liu, X. (2007). Geochemistry and geochronology of high-grade rocks from the Grove Mountains, East Antarctica: Evidence for an Early Neoproterozoic basement metamorphosed during a single Late Neoproterozoic/Cambrian tectonic cycle. *Precambrian Research*, *158*(1–2), 93–118. https://doi.org/10.1016/j.precamres.2007.04.005

Liu, Xiaochun, Hu, J., Zhao, Y., Lou, Y., Wei, C., & Liu, X. (2009). Late Neoproterozoic/Cambrian high-pressure mafic granulites from the Grove Mountains, East Antarctica: P–T–t path, collisional orogeny and implications for assembly of East Gondwana. *Precambrian Research*, *174*(1–2), 181–199. https://doi.org/10.1016/j.precamres.2009.07.001

Liu, Xiaohan, Zhao, Y., Liu, X., & Yu, L. (2003). Geology of the Grove Mountains in East Antarctica. *SCIENCE IN CHINA*, *46*(4), 305–319.

Lowry, A. R., & Pérez-Gussinyé, M. (2011). The role of crustal quartz in controlling Cordilleran deformation. *Nature*, *471*(7338), 353–357. https://doi.org/10.1038/nature09912

McBride, J. H. (1994). Structure of a continental strike-slip fault from deep seismic reflection: Walls Boundary fault, northern British Caledonides. *Journal of Geophysical Research: Solid Earth*, *99*(B12), 23985–24005.

Mikhalsky, E. V., Laiba, A. A., & Beliatsky, B. V. (2006). Tectonic subdivision of the Prince Charles Mountains: a review of geologic and isotopic data. *Antarctica*, 69–81.

Newman, G. A., & Alumbaugh, D. L. (2000). Three-dimensional magnetotelluric inversion using non-linear conjugate gradients. *Geophysical Journal International*, *140*(2), 410–424. https://doi.org/10.1046/j.1365-246x.2000.00007.x

Peacock, J. R., & Selway, K. (2016). Magnetotelluric investigation of the Vestfold Hills and Rauer Group, East Antarctica. *Journal of Geophysical Research: Solid Earth*, *121*(4), 2258–2273. https://doi.org/10.1002/2015JB012677

Powell, C. McA., & Pisarevsky, S. A. (2002). Late Neoproterozoic assembly of East Gondwana. *Geology*, *30*(1), 3. https://doi.org/10.1130/0091-7613(2002)030<0003:LNAOEG>2.0.CO;2

Reading, A. (2006). The seismic structure of Precambrian and early Palaeozoic terranes in the Lambert Glacier region, East Antarctica. *Earth and Planetary Science Letters*, *244*(1–2), 44–57. https://doi.org/10.1016/j.epsl.2006.01.031

Selway, K. (2014). On the Causes of Electrical Conductivity Anomalies in Tectonically Stable Lithosphere. *Surveys in Geophysics*, *35*(1), 219–257. https://doi.org/10.1007/s10712-013-9235-1

Shen, W., Wiens, D. A., Lloyd, A. J., & Nyblade, A. A. (2020). A Geothermal Heat Flux Map of Antarctica Empirically Constrained by Seismic Structure. *Geophysical Research Letters*, *47*(14). https://doi.org/10.1029/2020GL086955

Tarney, J., & Jones, C. E. (1994). Trace element geochemistry of orogenic igneous rocks and crustal growth models. *Journal of the Geological Society*, *151*(5), 855–868. https://doi.org/10.1144/gsjgs.151.5.0855

Tingey, R. (1991). The regional geology of Archaean and Proterozoic rocks in Antarctica. In *The geology of Antarctica* (pp. 1–73).

Torsvik, T. (2001). Rodinia refined or obscured: palaeomagnetism of the Malani igneous suite (NW India). *Precambrian Research*, *108*(3–4), 319–333. https://doi.org/10.1016/S0301-9268(01)00139-5

Von Huene, R., & Scholl, D. W. (1991). Observations at convergent margins concerning sediment subduction, subduction erosion, and the growth of continental crust. *Reviews of Geophysics*, *29*(3), 279–316.

Yoshida, Masaru, Jacobs, J., Santosh, M., & Rajesh, H. M. (2003). Role of Pan-African events in the Circum-East Antarctic Orogen of East Gondwana: a critical overview. In M. Yoshida, B. F. Windley, & S. Dasgupta (Eds.), *Proterozoic East Gondwana: Supercontinent*

Assembly and Breakup (Vol. 206, p. 0). Geological Society of London. https://doi.org/10.1144/GSL.SP.2003.206.01.05

Zhao, Y., Liu, X. H., Liu, X. C., & Song, B. (2003). Pan-African events in Prydz Bay, East Antarctica, and their implications for East Gondwana tectonics. In M. Yoshida, B. F. Windley, & S. Dasgupta (Eds.), *Proterozoic East Gondwana: Supercontinent Assembly and Breakup* (Vol. 206, p. 0). Geological Society of London. https://doi.org/10.1144/GSL.SP.2003.206.01.12

Zong, S., Ren, L., Wu, M., Xu, H., & Zhu, S. (2022). Whole-Rock Geochemistry, Zircon U-Pb geochronology and Lu-Hf isotopic constraints on metasedimentary rocks (Paragneisses) in Stornes Peninsula, Larsemann Hills，East Antarctica. *International Geology Review*, 1–17. https://doi.org/10.1080/00206814.2022.2045639

FIGURE CAPTIONS

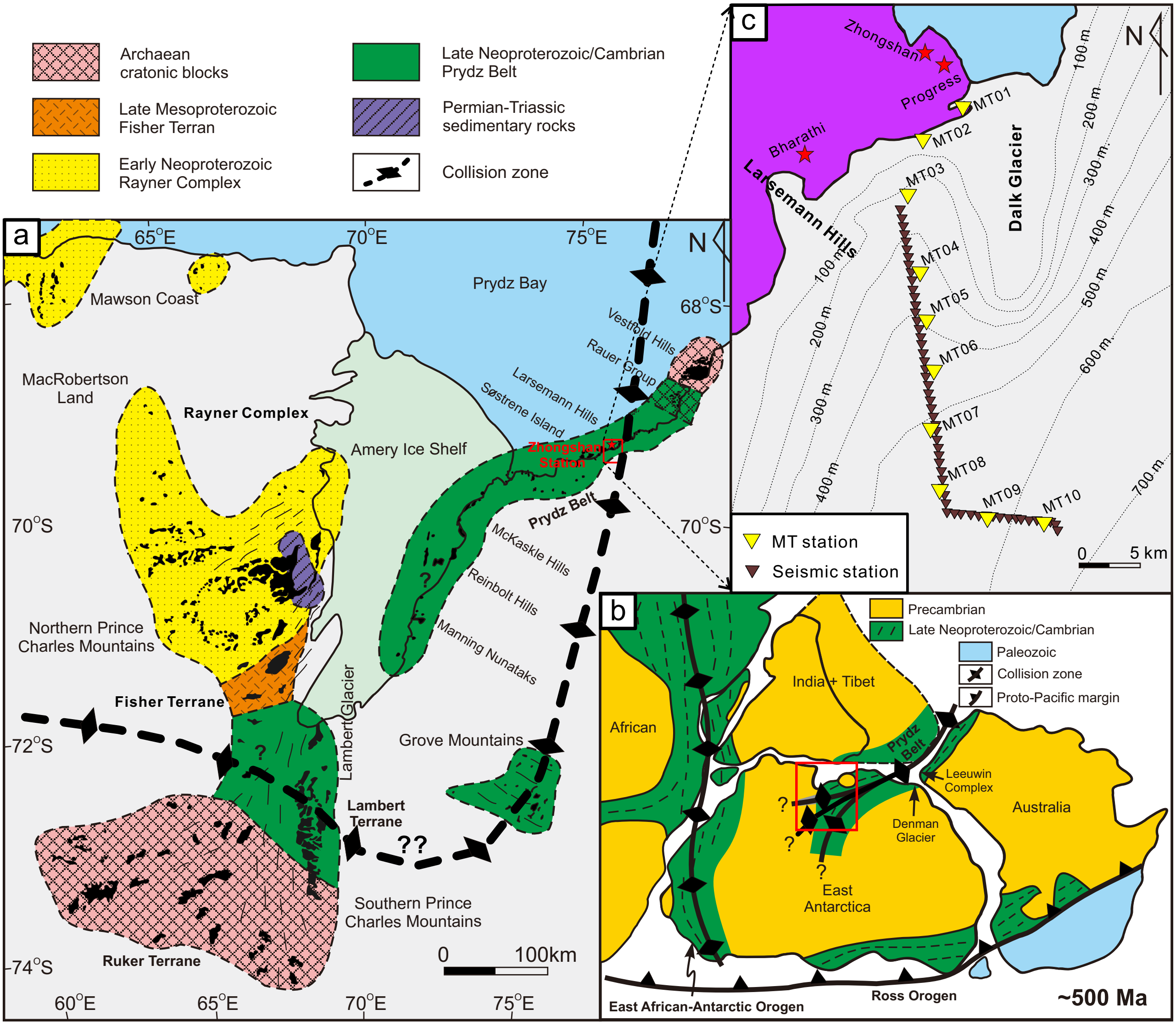
Figure 1. Geological map for the seismic and MT survey in the Larsemann Hills. (a) Geological sketch map of the Prydz Belt and adjacent areas, the black dashed curve indicates the Indo-Antarctica suture zone proposed by Gupta et al. (2021), (b) showing its location in the reconstruction of Gondwana at circa 500 Ma (Modified after Kelsey et al., 2008), (c) the short-period seismometers (brown triangles) and MT stations (yellow triangles) deployed in the Larsemann Hills, Prydz Bay, during CHINARE36.

Figure 2. Geophysical results. (a) The Moho depth and Poisson's ratio along the profile constrained from seismic events with Ms > 5.0 using H-k method; (b) CRF stacking image of curst structure along profile; (c) shear-wave velocity model for the ice sheet and uppermost curst; (d) resistivity model of curst structure along profile. The two dashed lines marked with 'F1' and 'F2' in (b) and (d) indicate two deep faults running through uppermost curst and Moho.

Figure 3. Cartoon of crustal structure in the Larsemann Hills, Prydz Bay. The Indo-Antarctic block subducted and collided with East Antarctic Carton, and the low resistivity channel caused by graphite and sulfite films along grain boundaries along the lithospheric suture zone (weak zone) within the crust-mantle transition zone as well the mid-lower crust.

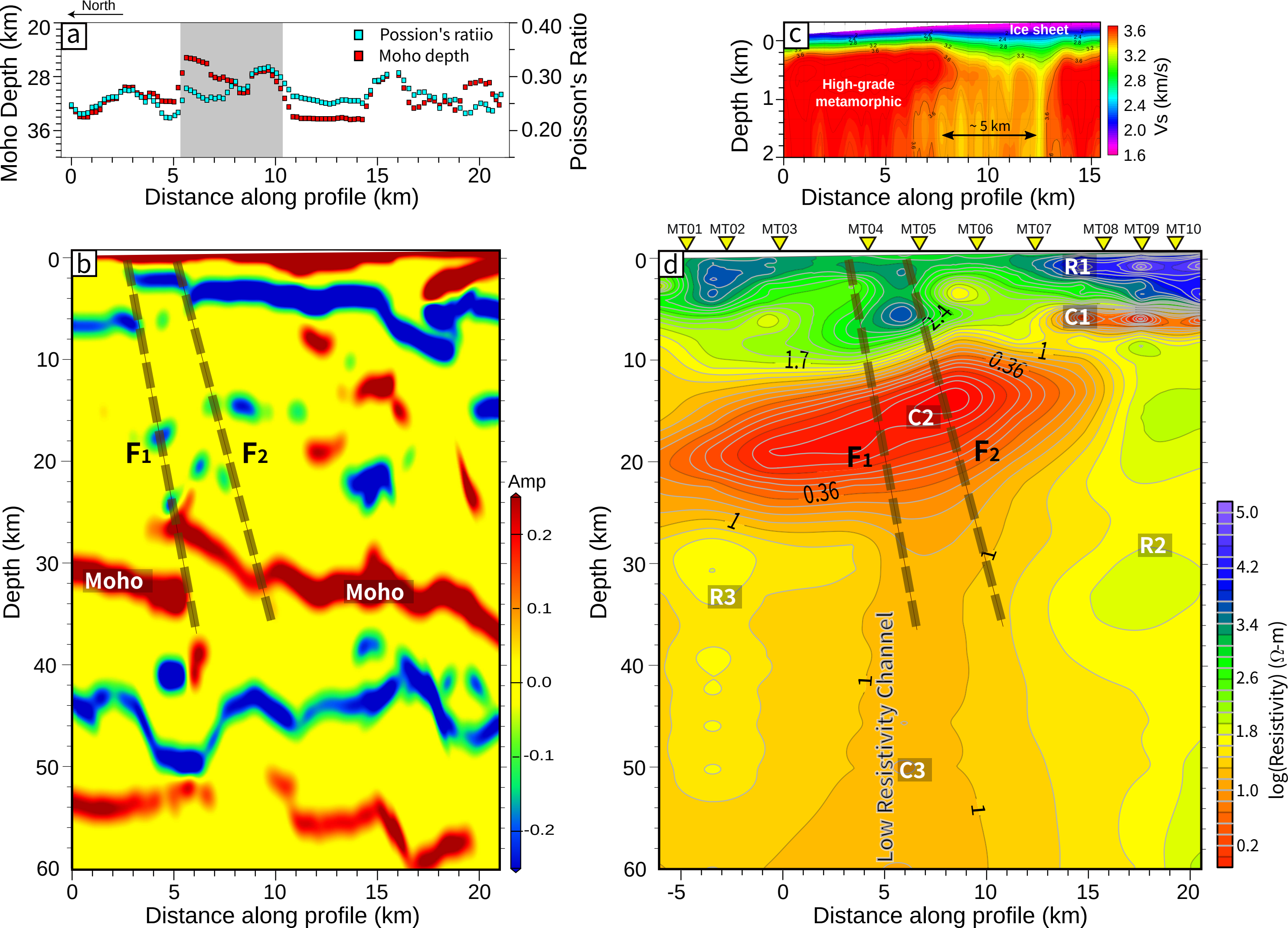
Supplemental Material. Supplementary Information provides the method of Coherent Receiver Function imaging technique under the Bayesian framework (CRF Method), and additional figures for data analysis and results (Figures S1-S6).

Figure 1.



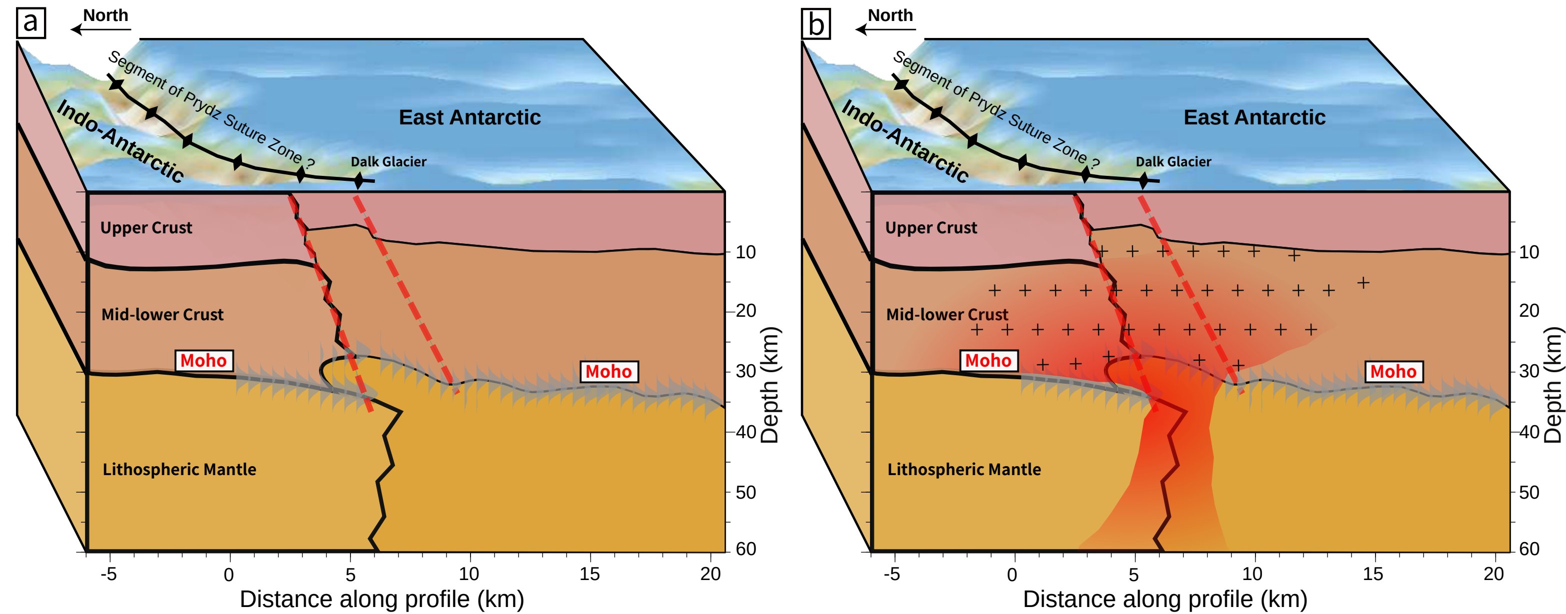
Archaean cratonic blocks
Late Mesoproterozoic Fisher Terran
Early Neoproterozoic Rayner Complex
Late Neoproterozoic/Cambrian Prydz Belt
Permian-Triassic sedimentary rocks
Collision zone
a
65°E
70°E
75°E
N
Mawson Coast
Prydz Bay
68°S
Vestfold Hills
Rauer Group
Larsemann Hills
Søstrene Island
MacRobertson Land
Rayner Complex
Amery Ice Shelf
Zhongshan Station
Prydz Belt
70°S
McKaskle Hills
Reinbolt Hills
Northern Prince Charles Mountains
Manning Nunataks
Fisher Terrane
Lambert Glacier
Grove Mountains
-72°S
Lambert Terrane
??
Southern Prince Charles Mountains
Ruker Terrane
-74°S
0
100km
60°E
65°E
70°E
75°E
c
Zhongshan
Progress
MT01
Bharathi
MT02
Larsemann Hills
MT03
Dalk Glacier
MT04
MT05
MT06
MT07
MT08
MT09
MT10
100 m
200 m
300 m
400 m
500 m
600 m
700 m
N
0
5 km
MT station
Seismic station
b
Precambrian
Late Neoproterozoic/Cambrian
Paleozoic
Collision zone
Proto-Pacific margin
African
India + Tibet
Prydz Belt
Leeuwin Complex
Denman Glacier
Australia
East Antarctica
East African-Antarctic Orogen
Ross Orogen
~500 Ma

Figure 2.



North
a
Possion's ratiio
Moho depth
Moho Depth (km)
Poisson's Ratio
Distance along profile (km)
c
Ice sheet
High-grade metamorphic
~ 5 km
Depth (km)
Vs (km/s)
Distance along profile (km)
b
F1
F2
Moho
Moho
Amp
Depth (km)
Distance along profile (km)
MT01
MT02
MT03
MT04
MT05
MT06
MT07
MT08
MT09
MT10
d
R1
C1
C2
F1
F2
R2
R3
C3
Low Resistivity Channel
Depth (km)
log(Resistivity) (Ω-m)
Distance along profile (km)

Figure 3.


a
North
Segment of Prydz Suture Zone ?
Indo-Antarctic
East Antarctic
Dalk Glacier
Upper Crust
Mid-lower Crust
Moho
Moho
Lithospheric Mantle
10
20
30
40
50
60
Depth (km)
-5
0
5
10
15
20
Distance along profile (km)
b
North
Segment of Prydz Suture Zone ?
Indo-Antarctic
East Antarctic
Dalk Glacier
Upper Crust
Mid-lower Crust
Moho
Moho
Lithospheric Mantle
10
20
30
40
50
60
Depth (km)
-5
0
5
10
15
20
Distance along profile (km)