Japanese-German joint airborne geophysical surveys around Syowa Station, Antarctica

Y. Nogi,[1] D. Steinhage,[2] K. Kitada,[3] S. Riedel,[2] W. Jokat,[2] K. Shiraishi,[1] and K. Shibuya[1]

[1]NIPR, 1-9-10 Kaga, Itabashi, Tokyo, 173-8515, Japan (nogi@nipr.ac.jp)
[2]Alfred Wegener Institute for Polar and Marine Research, Columbusstrasse, Bremerhaven, 27568, Germany
[3]Kobe University, 1-1 Rokkodai, Nada-ku, Kobe, 657-8501, Japan

Summary The area around Syowa Station, the Japanese Antarctic wintering Station in Lützow- Holm Bay, is considered to be a junction of Africa, India, Madagascar, and Antarctic continents from the reconstruction model of Gondwana. Therefore this area is a key to investigate the formation and fragmentation of Gondwana. To reveal the tectonic evolution related to Gondwana formation and breakup in this area, joint Japanese-German airborne geophysical surveys around Syowa Station had been conducted in January 2006 during the 47th Japanese Antarctic Research Expedition. Ice radar, magnetic, and gravity data are obtained onshore and offshore areas using the AWI owned, Dornier aircraft (Polar-2) and the outline of the results are presented. Several characteristic features possibly related to the tectonic evolution of Gondwana are inferred from magnetic and gravity anomaly maps. The tectonic evolution in this area are discussed.

Citation: Nogi, Y., D. Steinhage, K. Kitada, S. Riedel, W. Jokat, K. Shiraishi and K. Shibuya (2007), Japanese-German joint airborne geophysical surveys around Syowa Station, Antarctica, in Antarctica: A Keystone in a Changing World – Online Proceedings of the 10th ISAES X, edited by A. K. Cooper and C. R. Raymond et al., USGS Open-File Report 2007-1047, Extended Abstract 065, 4 p.

Introduction

The evolution of Antarctica and the Antarctic Ocean is vital to understanding the growth and breakup of super continent Gondwana. The reconstruction models of Gondwana have been established by many authors using geophysical data set as well as geological data (e.g. Norton and Sclater, 1978). The area around Syowa Station, the Japanese Antarctic wintering Station in Lützow- Holm Bay, is considered to be a junction of Africa, India, Madagascar, and Antarctic continents from the reconstruction models of Gondwana. Therefore this area is a key to investigate the formation and fragmentation of Gondwana. However, the tectonic evolution is still speculative because geological evidence is limited to a few isolated outcrops and the coverage with geophysical surveys in this area is poor.

Joint Japanese-German airborne geophysical surveys around Syowa Station had been conducted in January 2006 during the 47th Japanese Antarctic Research Expedition to reveal tectonic evolution of the area around Syowa Station. The observation lines are shown in Figure 1.

Data

The airborne geophysical surveys had been made along almost N-S observation lines with spacing of about 20 km. Ice radar measurements had been carried out onshore area and ice thickness data are obtained. Bed rock topography are estimated from RAMP surface elevation data set by subtracting ice thickness. Magnetic and gravity measurements had been conducted both onshore and offshore areas. Magnetic anomalies are determined after correcting diurnal geomagnetic variations at Syowa Station. Precise positions of the aircraft are determined using DGPS techniques and free-air gravity anomalies are also obtained. Those data are girdded and plotted using GMT software (Wessel and Smith, 1998).

Results

The results of bed rock topography, gravity and magnetic anomalies are shown in Figures 2, 3 and 4, respectively. Characteristic features possibly related to the tectonic evolution from the results are summarized as followings..

- Large negative gravity anomalies are observed along the Shirase Glacier (A in Figure 3) and those almost correspond to deep bed rock topography.
- Two sets of positive and negative gravity anomalies are shown along ocean-continental transition (B in Figure 3). However, magnetic anomalies along ocean-continental transition indicate only one set.
- NW-SE trending positive magnetic anomalies are observed between 40°E and 43°E near Antarctic continental margin (A in Figure 4). Those almost correspond to the transitional zone from Amphibolite to Granulite faces in the Lützow-Holm Complex.
- NE-SW trending magnetic anomalies in offshore area possibly indicate magnetic anomaly lineations (B in Figure 4).
- Positive magnetic anomalies surrounded by negative ones are observed around Cape Hinode (C in Figure 4).

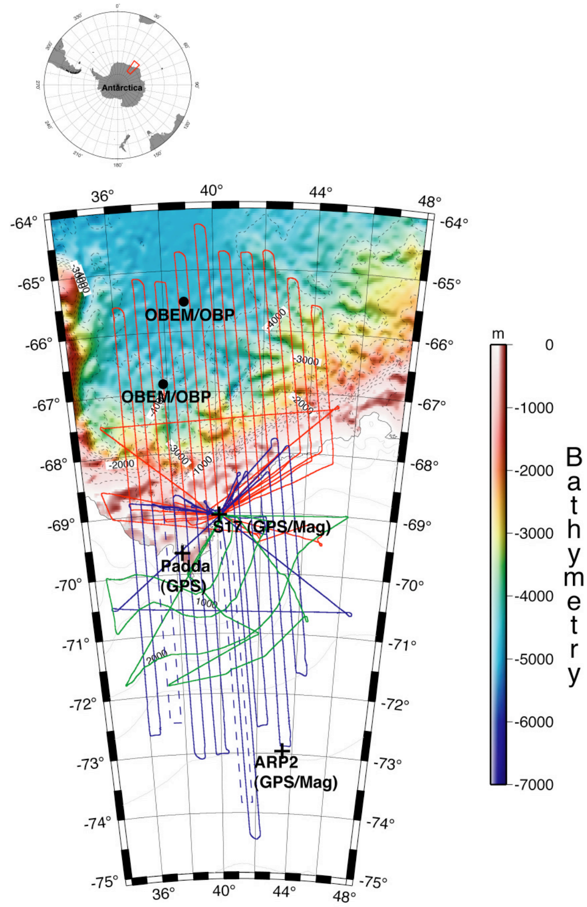

Figure 1. Airborne geophysical observation lines during the 47th Japanese Antarctic Research Expedition (red lines: magnetic and gravity measurements, blue lines: magnetic, gravity and ice radar measurements, green lines: magnetic and ice radar measurements had been conducted). Crosses show GPS and geomagnetic reference sites (Padda, S17 and ARP2). Positions of OBEM (Ocean Bottom Electro-Magnetometer) and OBP (Ocean Bottom Pressure-gauge) are also indicated.

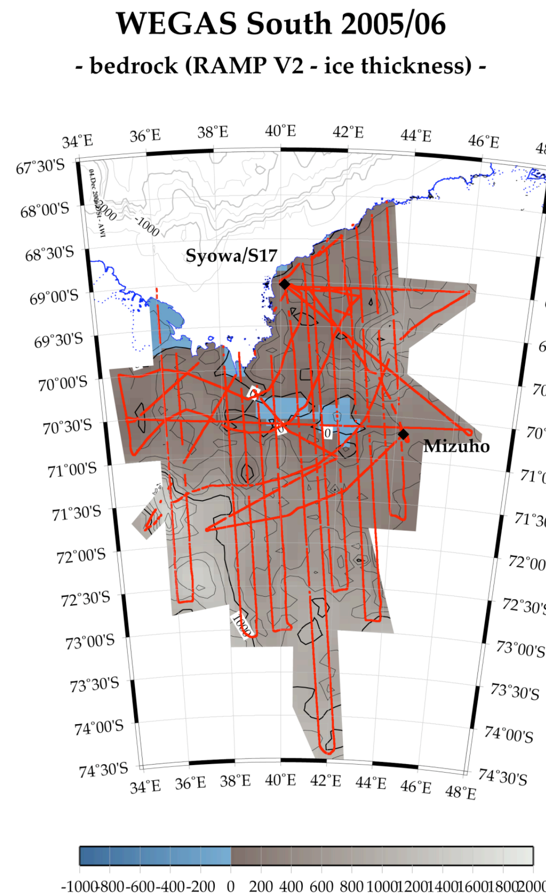

Figure 2. Bed rock topography.

Discussion

Large negative gravity anomalies and deep bed topography along the Shirase Glacier (A in Figure 4) possibly indicate major geological boundaries. It has been inferred that the peak metamorphic grade of the Lützow-Holm Complex progressively increases in a southwestern direction from amphibolite-facies to granulite-facies conditions and higher metamorphic grade are observed near the Shirase Glacier (Hiroi et al., 1983). Therefore large negative gravity anomalies and deep bed topography along the Shirase Glacier most likely delineate southwestern boundary of the Lützow-Holm Complex.

Characteristic magnetic anomaly features around Cape Hinode (C in Figure 5) may indicate an allochthonous unit in the Lützow-Holm Complex. The main orogenic activities of the Lützow-Holm Complex took place during the Latest Proterozoic ro Early Paleozoic times. However, older rocks around 1000 Ma were documented at Cape Hinode within the Lützow-Holm Complex (Shiraishi et al., 1994). Magnetic anomaly data will provide new constraints for constructing tectonic evolution model in this area.

NE-SW trending magnetic anomalies (B in Figure 5) possibly represent M sequence magnetic anomaly lineations. ENE-WSW and E-W magnetic anomaly lineation trends, possibly belonging to the Mesozoic magnetic anomaly

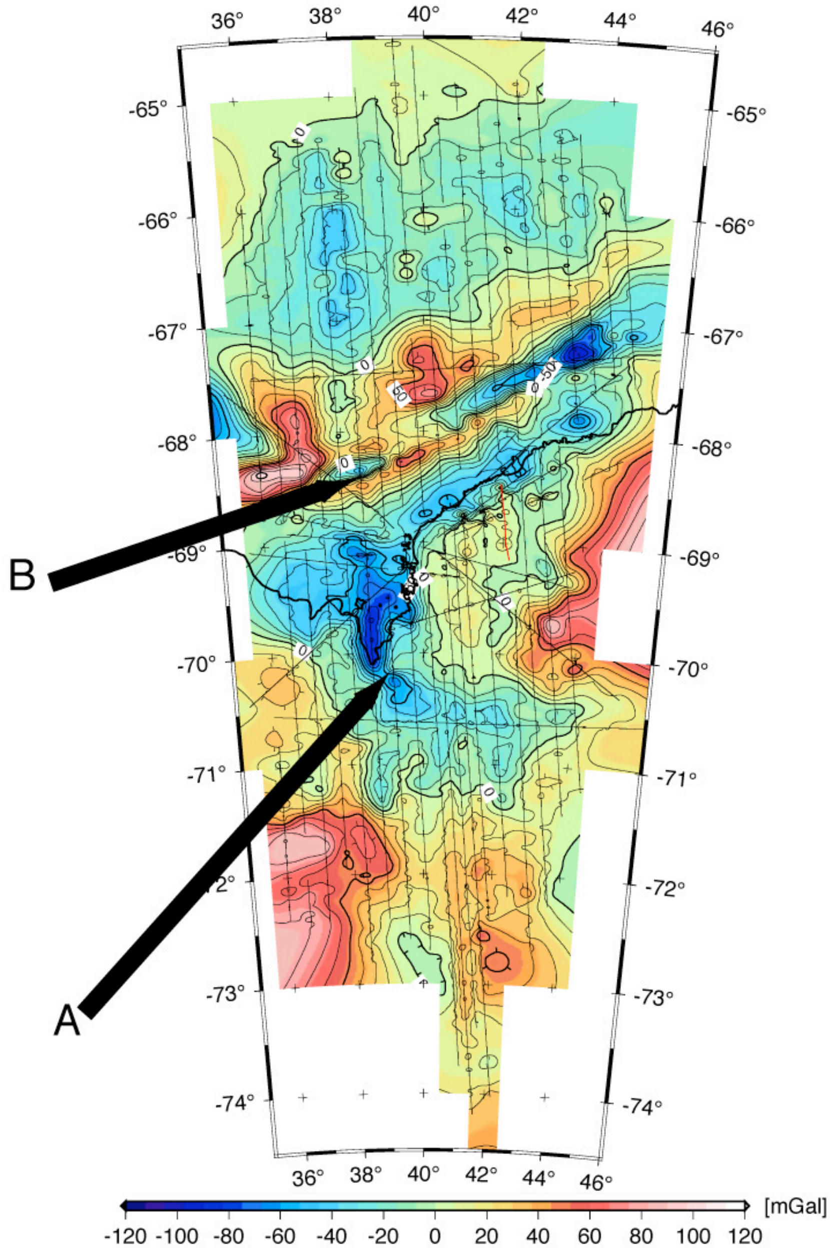

Figure 3. Gravity anomalies.

lineation sequence, accompanied by the NW-SE and NNW-SSE trending fracture zones are deduced from vector magnetic anomalies just seaward of the continental slope of Antarctica to the east of Gunnerus Ridge (Nogi et al. 1996). NE-SW trending magnetic anomalies show similar strikes of magnetic anomalies from vector magnetic anomalies.

Two sets of positive and negative gravity along ocean-continental transition (B in Figure 4) possibly reflect initial breakup conditions of Gondwana. Magnetic anomalies along ocean-continental transition do not show two sets of positive and negative magnetic anomalies. However, possible magnetic anomaly lineation trends in this area are almost parallel to the trends of gravity anomalies along ocean-continental transition and those imply that the direction of initial extension are normal to present coast line of Antarctica in this area. Two sets of positive and negative gravity along ocean-continental transition may suggest initial extension of Gondwana breakup.

Conclusions

The outline of ice thickness, bed rock topography, gravity and magnetic anomaly results in the area around Syowa Station are shown. Characteristic features from the results are indicated and discussed. These results provide new constraints on the tectonic evolution in the area a junction of Africa, India, Madagascar, and Antarctic continents of Gondwana. Further data analysis are carrying out and detailed discussion will be made based on those results.

Acknowledgements. We would like to thank the flight crews for their excellent support during the field season. Y.N. also thanks the members of the JARE-47 and crews of the icebreaker Shirase for their kind help during operations.

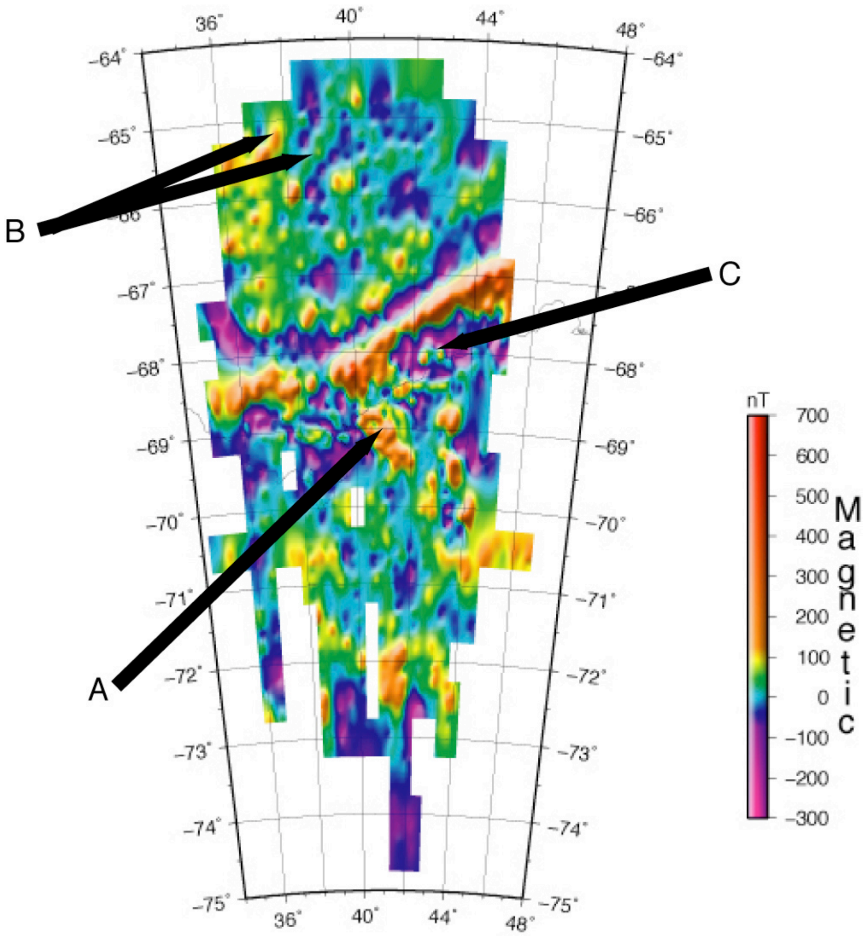

Figure 4. Magnetic anomalies.

References

Hiroi, Y., K. Shiraishi, K. Yanai and K. Kizaki (1983), Geology and petrology of Prince Olav Coasts, East Antarctica, Antarctic Earth Science, ed. by R.L. Oliver et al., Canberra, Aust. Acad. Sci., 32-35.

Nogi, Y., N. Seama, N. Isezaki and Y. Fukuda (1996), Magnetic anomaly lineations and fracture zones deduced from vector magnetic anomalies in the West Enderby Basin, ed. by B.C. Storey, E.C. King and R.A. Livermore R.A., Weddell Sea Tectonics and Gondwana Break-up, Geol. Soc. Spec. Pub. 108, 265-273

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

Shiraishi, K., D.J. Ellis, Y. Hiroi, Y. Fannning, Y. Motoyoshi and Y. Nakai (1994), Cambrian orogenic belt in East Antarctica and Sri Lanka: implications for Gondwana assembly, J. Geol., 102, 47-65.

Wessel,.P. and W.H.F.Smith (1998), New improved version of the Generic Mapping Tools released, EOS Trans. AGU, 79, 579.