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Magnetic Anomaly Map for Bharati Promontory, Larsemann Hills, East Antarctica

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ABSTRACT

Total magnetic field measurements were made through foot traverses using Proton Precision Magnetometer (PPM) and magnetic anomaly map has been compiled for Bharati Island, Larsemann Hills, East Antarctica. The magnetic field anomalies are confined to NE-SW ridges which are rich in magnetite bearing gneisses/ amphibolitic gneisses. These zones represent a single litho-unit in folded form or three independent magnetite rich rock units. In conjunction with other geophysical and geological information, the magnetic anomaly map would facilitate further tectonic studies and planning geophysical experiments in adjacent regions.

Keywords: Bharati, Promontory, Antarctica, Magnetic Anomaly, magnetite

INTRODUCTION

Antarctica is a key element in the earth's geodynamic and tectonic system. The east Antarctica region was once conjugate to southern part of India (Powell et al., 1988) i.e. India's southeastern edge and East Antarctica's edge were juxtaposed together and these two margins possess similar geological history. The transect of geophysical data along these margins can address multifold objectives such as the Mesoproterozoic accretion processes, strengthening breakup theory, and understanding the intricacies pertaining to geodynamics. Based on gravity-magnetic modeling constrained by seismic studies and volcanic rocks found in boreholes, Mishra et al. (1999) inferred that the margins are characterized by Permian-Triassic-Cretaceous sediments of same density and thickness. Using new seafloor isochrones between the Gunnerus Ridge and Bruce Rice, Gaina et al. (2007) presented plate reconstruction models for early breakup between India and Antarctica.

Reconstructions for the Eastern Gondwanaland (Powell et al. 1988) indicate that the present day continental margin of East Antarctica agrees well with the ECMI along 2000 m bathymetry between 35°E and 95°E. Golynsky et al. (2002) used airborne magnetic data to identify a prominent positive magnetic anomaly belt named as Antarctic Continental Margin Magnetic Anomaly (ACMMA) with 120 km width, 150-600 nT anomaly which can be taken as a counter part of the positive magnetic anomaly belt observed along the Indian east coast (ECMI). Both these anomaly belts run along the 2000 m bathymetry contour line strengthening conjugate nature of the two margins. Further, the conjugate nature of these margins can be substantiated from the present admittance studies (Shyam Chand et al., 2001). To obtain detailed shallow sub surface features and composition, magnetic study has been undertaken in the vicinity of proposed Indian station named Bharati.

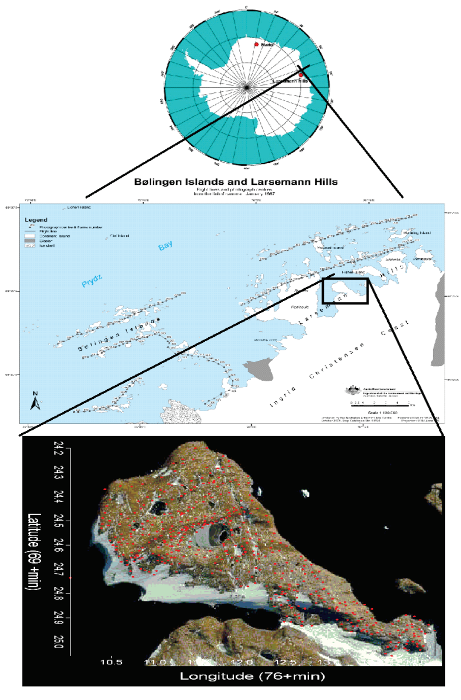

Fig. 1. Map showing 410 locations (red dots) of total magnetic filed measurements in Bharati promontory in Larsemann Hill region superposed on an aerial imagery. The Larsemann Hill area and Bharati Promontory are shown as insets in the top and middle (Bolingen Islands and Larsemann Hills, published by Australian Government Antarctic Division) figures respectively

Bharati promontory is an ice-free hilly region with maximum elevation of 110 m, confined to 76° 10'-76° 14.5' E and 69° 24' - 69° 25.5' S, covering an area of about 50 sq km. This area is located approximately halfway between the Vestfold hills and the Amery Ice Shelf (between Stornes and Broknes peninsula, Figure 1) in East Antarctica. Total magnetic field (F) was measured at 410 locations during March 2007 austral summer, XXVI Indian Antarctica expedition. The measurement locations are shown in Figure.1 superposed on aerial imagery. Digital Fluxgate Magnetometer (DFM) was continuously operated to facilitate the diurnal variation correction in the total magnetic field.

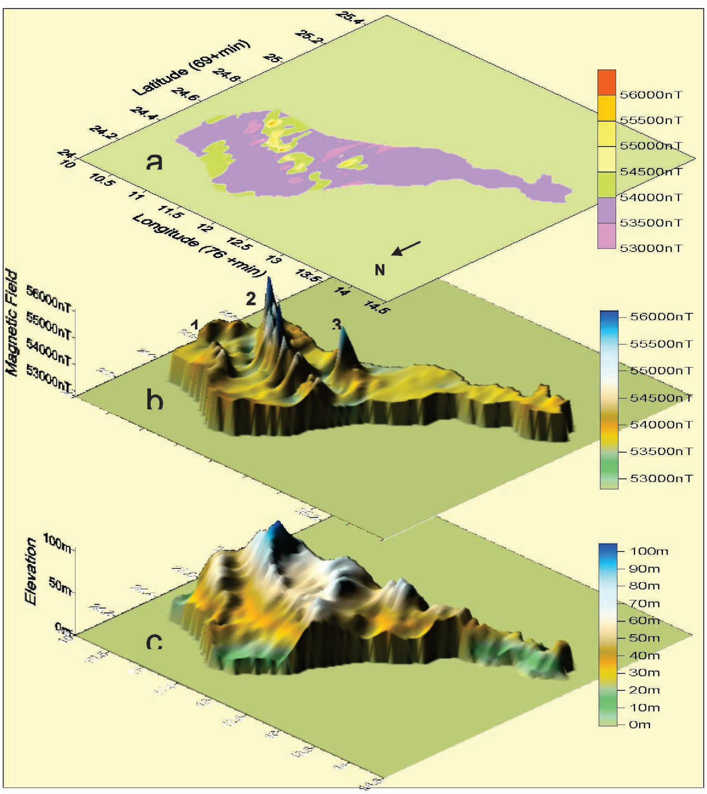

Fig.2: (a) Total magnetic field contour; (b)coloured surface relief maps for Bharati promontory, Larsemann Hill, East Antarctica, corresponding to the measurements at 410 locations as shown in Figure1; and (c)The elevation relief map in WGS84.

The magnetic data were utilized to prepare a contour map (Fig. 2a) and perspective view of the same (shown in Figure.2b). The elevation map shown in Figure 2c has been prepared using elevations measured at 410 sites along with longitude and latitude, using Garmin single frequency GPS receiver, in autonomous mode and all the coordinates are in WGS84.

The minimum, maximum and median values of total magnetic field are around 52000 nT, 53700 nT and 56600 nT, respectively. The range is around 4600 nT which is significantly high. The diurnal corrections have been applied. To get the Total intensity anomaly, we have applied International Geomagnetic reference field 2001 (IGRF) to the diurnally corrected total magnetic field data. The computed magnetic elements are given in Table 1.

As seen from magnetic field contour map (Fig. 2a), and corresponding colored surface relief map in Figure 2b, it is observed that the high magnetic-filed anomaly regions are concentrated over some pockets which are located on high ridges seen in the elevation relief map. This can be visualized from the Figures 2b & c where perspective view of magnetic anomalies and elevation are simultaneously shown to see the spatial correlation. In the southern part of the promontory the magnetic field values generally correspond to background values and no significant anomalies were observed.

The causative source of the anomaly seems to be at very shallow depth as its observed horizontal gradient is of about 1000 nT per 50 m at some locations. The most likely cause for the magnetic anomaly can be the magnetite bearing gneisses/amphibolitic gneisses which are present as NE-SW trending bands in the region (Pandit and Amit, 2007). As seen from the Geology of the Larsemann Hills – Lithology (published by Australian Government Antarctic Division) in Figure 3, these NE-SW ridges are characterized by garnet-magnetite-biotite gneisses. There is evidence of oxidation of iron rich material as seen in the form of limonitic surface exposures. As compared to Schirmachar area around Maitri, it is different because no magnetite bearing rocks have been reported from there (Pandit and Amit, 2007).

The magnetic field anomalies marked as 1, 2 and 3 in Figure 2, either represent a single litho-unit in folded terrain (appearing at different places on the erosional surface) or three (1, 2 and 3) independent

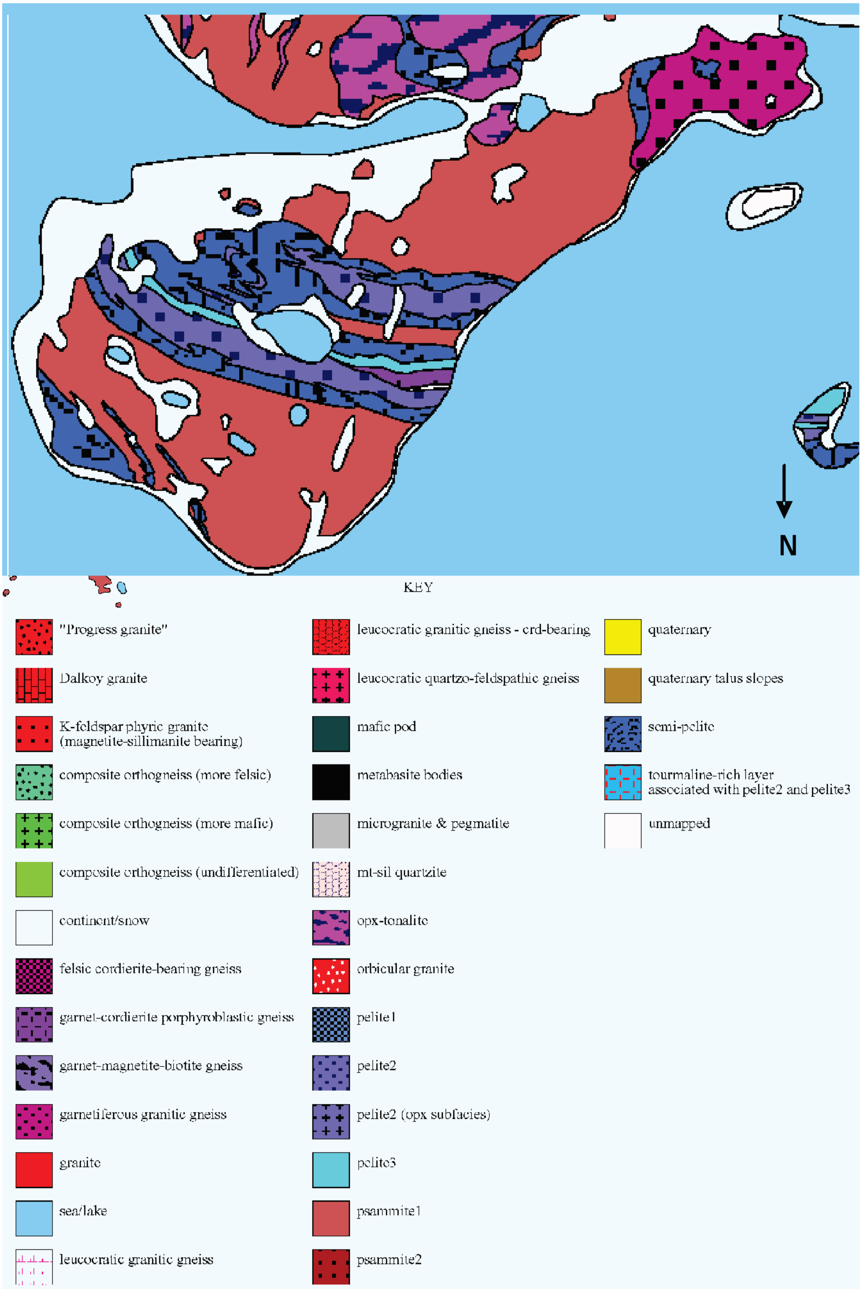

Fig.3: Geology map of the Bharati Promontory (extracted from the Geology of the Larsemann Hills – Lithology, published by Australian Government Antarctic Division)

Table 1–Magnetic field elements at Bharti Promontory, computed from IGRF 2001

At Bharti Promontory	Declination + East - West	Inclination + Down - Up	Horizontal Intensity	North Component + North - South	East Component + East - West	Vertical Component + Down - Up	Total Field
3/11/2007	- 78° 33'	- 71° 27'	17,144.5 nT	3405.7 nT	-16,802.8 nT	-51,102.2 nT	53,901.4 nT

Source: National Geophysical Data Centre (NGDC)

magnetite rich rock units. The observed anomalies vary in dimension and magnitude due to complex geological processes such as multiple episodes of deformation and shearing. As seen from the Table 1, the total magnetic field mainly consists of vertical component (~ 51000 nT) and bodies causing the magnetic anomaly have vertical polarization and can be modeled easily. To understand the intricacies and quantitative modeling, detailed geological (petrologic, structural and geo-chemical) studies, supplemented by other geophysical techniques such as gravity, Magneto Telluric (MT), LMT etc. required to be carried out.

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