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BASEMENT HETEROGENEITY AND SEDIMENT THICKNESS OF KARBI-ANGLONG ASSAM, PARTS OF NORTH EAST INDIA INFERENCE FROM GRAVITY-MAGNETIC DATA

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ABSTRACT Karbi - Anglong forms the southern extremity of Mikir massif, represent an uplifted detached block of Shillong plateau, North East India comprising Precambrian Crystalline rocks of Gneissic complex and fluvial sediments of quaternary age. The gravity and magnetic surveys in the area brought out the subsurface structures and basement heterogeneity. The results of 2D subsurface modelling and the Spectral analysis of both Gravity-Magnetic data brought out the basement configuration and the overlying average sedimentary thickness ranging from 400m to 1000m and these depths are good agreement with Werner depth solutions obtained from gravity-magnetic data.

KEYWORDS : Gravity, Magnetic, subsurface structures, 2D modeling, Spectral Analysis, Karbi-Anglong.

Introduction:

The study area, Karbi - Anglong forms the southern extremity of Mikir massif, represent an uplifted detached block of Shillong plateau, North East India. The spatial coordinates of the area are 26^0 00' - 26^0 15'N Latitude and 93^0 00' - 93^0 15'E Longitude. The general geological map of the study area overlaid with obtained Gravity-Magnetic profiles shown in (Fig.1). Tectonically, the entire North Eastern region of India is active due to the collision of Eurasian plate with Indian plate and the eastern subduction interface of North-drifting Indian plate (Mukhopadhyay, 1974; Kayal, 2006; Seno and Rehman, 2011; Pathak, 2014). The structural complexity and the basement configuration of the present area was not clearly reflected in both the 10 mGal Gravity map (NGRI, 1978) and Revision of Bouguer gravity Map of India (RGMI, 2006), due to Paucity of data. In order to know the shallow subsurface information and basement structures of the study area, geophysical surveys have been carried out by employing gravity and magnetic surveys.

Objective:

To understand the shallow subsurface information and basement heterogeneity of the Karbi-Anglong area, two Gravity-Magnetic profiles have been carried out and interpreted to decipher the thickness of the overlying sediments and the nature of the underlying basement.

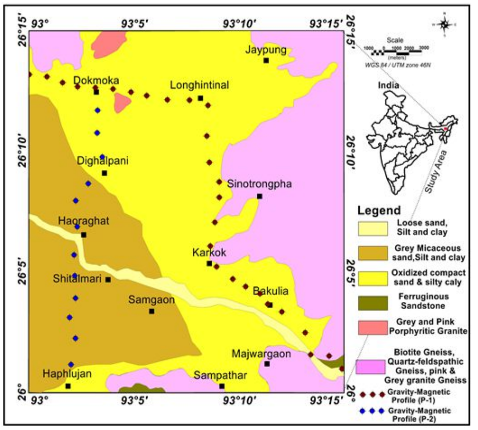

Fig.1. Simplified geological map of the study area (modified after geological map series, GSI, NER, 1979) overlaid with gravity-magnetic profiles over Karbi - Anglong area of North Eastern Indian region.

Geophysical Data and Methodology: Geologically the study area can be demarcated in to two Groups i.e. Precambrian Crystalline rocks and fluvial sediments of quaternary age. The crystalline rocks include the Gneissic Complex of Archean to Proterozoic age subjected to metamorphism and several phases of deformation (Mazumder, 1976; Murthy, 1976). The eastern portion, western corner and southern part predominantly covered by the exposed Gneissic, granite intrusive rocks and rest of the area is occupied by Quaternary alluvial sediments of Brahmaputra basin.

The Bouguer gravity anomaly map (GSI-NGRI, 2006) shows an overall variation of -16 mGal ranging from maximum of -56 mGal gravity high (GH) anomaly zone noticed east of Bakulia at southeastern part over exposed Gneissic rocks and minimum of -72 mGal gravity low (GL) anomaly zone observed west of Dokmoka, northwest portion of the study area and the central area broadly demarcated by gravity gradient (GG) zone (Fig.2a). Since the available gravity anomaly map represents mostly the regional and longer wavelength anomalies due to its spars data density. To understand the nature of shallow subsurface features and thickness of overlying sediments, we have carried out gravity-Magnetic surveys along two profiles (P-1 & P-2) with close spacing of 1 to 1.5 km station interval using Autograv gravimeter (CG-5) and Total Field Magnetometer (GSM-19T) over the covered sediments of the study area (Fig.2b & c). The observed gravity data were corrected to instrument drift and reduced to mean sea level (m.s.l) with an average crustal density of 2670 kg/m^3 and connected to the established gravity base at Nagaon circuit house. The gravity formula of 1980 was used for calculation of the theoretical gravity. After applying all the necessary corrections such as base corrections, free air correction, Bouguer corrections for Gravity data and Diurnal corrections and main field correction using International Geomagnetic Reference Field (IGRF) for total field magnetic data. Both Gravity and Magnetic data were taken for interpretation by transforming them in to frequency domain using Fourier transformation. The two profiles data was subjected to spectral analysis to obtain different interface depths. 2D modelling has been also attempted to decipher subsurface gravity- magnetic signatures of different lithological units of the study region.

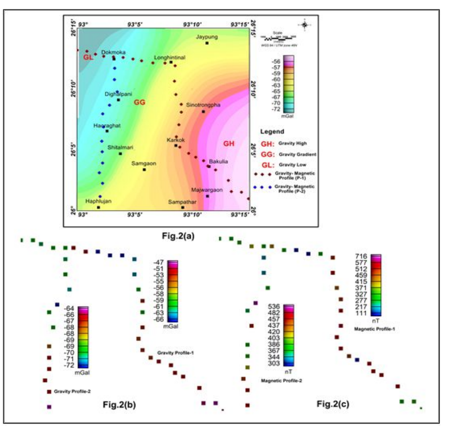

Fig.2 (a). Map showing the Bouguer gravity anomaly map digitized from gravity map series of India with 5mGal (GSI-NGRI,2006), 2(b). Gravity profiles over Karbi-Anglong area (P-1 & P-2) and 2(c). Magnetic profiles over Karbi-Anglong area (P-1 & P-2) and their anomaly distribution over different litho-units.

Gravity and Magnetic Profile (P-1): Geophysical surveys comprising of Gravity and Magnetic methods were employed over the covered alluvium sediments of Karbi-Anglong area along profile (P-1). Gravity-Magnetic data were acquired with station interval of 1 to 1.5km spacing along the profile (P-1) covering an area of 39.75km, starts from northwest of Dokmoka to southeast of Majwargaon. The complete Bouguer anomaly and magnetic anomalies were reduced after applying all the necessary corrections. The gravity profile (P-1) shows an overall variation of 19mGal due to lateral density heterogeneities ranging from maximum anomaly of -47 mGal observed southeast of Bakulia due to the underlying high density rocks or may be the less thickness of overlying sediments and minimum of -66mGal noticed towards northwest of Dokmoka due to low density formations or may be the thick overlying sediments (Fig.2a). These gravity anomaly ranges are well correlated with Bouguer anomaly Map (5mGal). The magnetic profile (P-1) has brought out varying anomaly pattern over different lithological formations due to susceptibility contrast. The measured Total field magnetic anomalies along the profile (P-1) are varying from 111nT to 716 nT. In general central part of the profile from Longhintinal to southeast of Bakulia is characterised by high magnetic anomalies due to high susceptibility basement structures whereas the western and southern corners are represented by broadly low intensity magnetic anomalies.

Gravity and Magnetic Profile (P-2): The north south profile (P-2) has also been carried out from Dokomoka to Haphljan with station interval of 1 to 1.5km spacing along the profile covering an area of 22.5km over sediments. The gravity profile (P-2) indicates a total variation of 8mGal due to density contrast along the profile and the minimum value of -72mGal observed south of Dokmoka whereas south of Shitalmari increases the gravity anomalies gradually and attained maximum of -64mGal due to high density underlying Gneissic basement rocks. The results obtained from both the gravity profiles reveals that high density anomalies continuing from southwestern part to southeastern portion indicates that the nature of the basement configuration characterised by the high density underlying Gneissic rocks.

Spectral Analysis of Gravity and Magnetic profiles (P-1 & P-2): The obtained gravity and magnetic profile data (P-1 & P-2) have been computed for spectral analysis to resolve depth to the sources of gravity and magnetic interface depths based on the variation of densities and susceptibility contrast (Spector, 1970; Naidu, 1972). The estimated gravity and magnetic interface depths are very useful to understand the depth extension and nature of the causative source of the study area. The computed radially average power spectrum of gravity profiles estimated the average interface depths of gravity profile (P-1) as 1.12km and 0.93km for (P-2), whereas the estimated magnetic interfaces of magnetic profile (P-1) as 1.13 and 0.84km for magnetic profile (P-2).

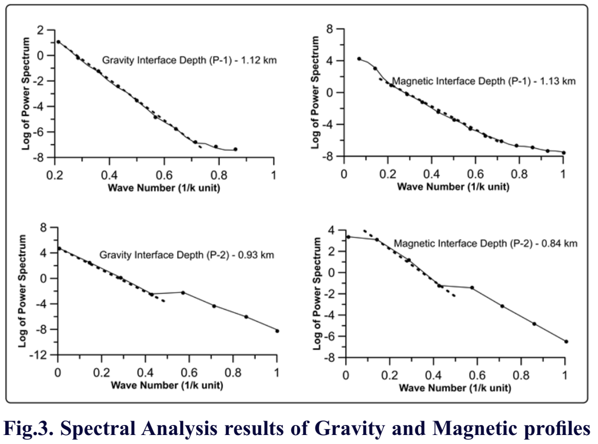

Fig.3. Spectral Analysis results of Gravity and Magnetic profiles (P-1: Gravity-Magnetic profile & P-2: Gravity-Magnetic profile).

Werner P-Depth solutions of Gravity and Magnetic profiles (P-1 & P-2): To understand the nature of the signatures of gravity and magnetic anomalies along two profiles over exposed alluvium cover of Karbi-Anglong, Werner P-Depth solutions were computed by employing Hartmen (1971) Werner Deconvolution technique for the potential field data. The results of the depth solutions derived from the Werner technique are shown in Fig. (4). The estimated Werner depth solutions represents source depth variations along the profiles reveals that depth to the basement along the profiles varying from 400m to 1000m and also gives the undulations in the thickness of overlying sediments.

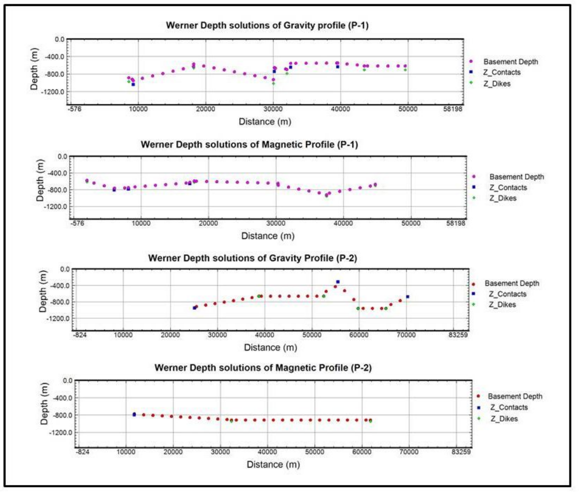

Fig.4. Werner P-DEPTH modeling results along Gravity and Magnetic profiles (P-1 & P-2).

2D Subsurface modeling along gravity profiles (P-1 & P-2): An attempt has been made to construct a 2D subsurface modeling along gravity profiles to understand the nature of the underlying basement and to know the thickness of the overlying sediments of the study area by using Gym-sys module of Geosoft software. The gravity profile modeling (P-1) has been carried out by assuming the density of Alluvium as 2250 kg/m^3 and 2690 kg/m^3 for the underlying Gneissic basement rocks. A fair match between the observed gravity profile and the computed curve with an RMS error of 0.099 was obtained. The modeling results depict thickness of overlying sediments and the underlying basement heterogeneities are shown in Fig. 5(a). The computed sedimentary thickness are varying from 65m to 850m, at south eastern part around Karkok the sedimentary thickness is very shallow and further southeast the sedimentary thickness are increasing gradually. The selected gravity profile (P-2) modeled by taking in to consideration of gravity interface depths obtained from spectral analysis and assumed average densities of overlying sediments and underlying gneissic rocks as 2250 kg/m^3 and 2690 kg/m^3 respectively. The observed gravity anomaly is fairly good match with the computed curve with RMS error of 0.063 was obtained and the model brought out thickness of overlying sediments and underlying Gneissic formations of Karbi - Anglong area varying from 0.8 km to 1.1km.

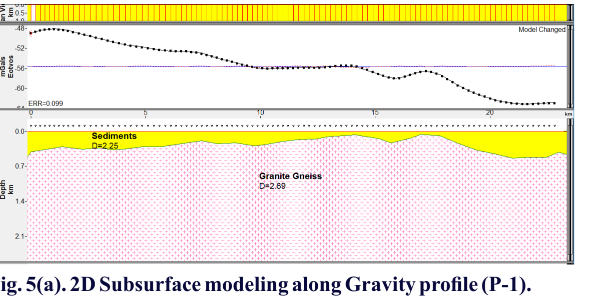

Fig. 5(a). 2D Subsurface modeling along Gravity profile (P-1).

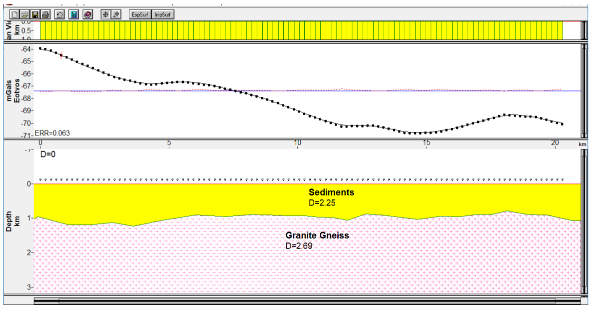

Fig. 5(b). 2D Subsurface modeling along Gravity profile (P-2).

Results and conclusions: The gravity and magnetic profile analysis of the Karbi - Anglong area brought out the nature of the subsurface causative source and the underlying basement heterogeneities. The results obtained from both the gravity and magnetic profiles reveals that high density formations associated with moderately high susceptibility anomalies continuing from southwestern part to southeastern portion indicates that the nature of the basement configuration characterised by high density underlying Gneissic rocks.

The results of Spectral analysis of both Gravity-Magnetic data brings out the average subsurface interface depths ranging from 0.8 km to 1.13km and the computed Werner depth solutions are varying from 400 m to 1000 m.

The 2D subsurface modeling results of two gravity profiles clearly brought out the overlying sedimentary thickness and underlying basement heterogeneities indicates that northern and eastern portions having relatively shallow sediments and gradually increasing the thickness of the sediments towards south and southwestern part of the study area.

References

1. GSI – NGRI Gravity Map series of India (RGMI - 2006): Published by Geol. Survey of India.
2. Hartman RR, Tesky DJ, and Friedberg JL 1971 A system for rapid digital aeromagnetic interpretation; Geophysics, 36, 891- 918.
3. Kayal, J.R., Arefiev, S.S., Baruah, S., Hazarika, D., Gogoi, N., Chowdhury, S.N., and Kalita, S., (2006): Shillong Plateau earthquake in northeast India region: Complex tectonic model. Curr.Sci., v.91(1), pp.109-114.
4. Mazumder, S.K.,(1976): A summary of the Precambrian geology of the Khasi hills, Meghalaya. Geol.Surv. India, Misc. Publ., No.23(Part II), pp.311-334.
5. Mukhopadhyay, M., (1974): Relationship of Gravity and Seismicity to Tectonics in Northeastern India, unpubl. Ph.D. thesis, Indian school of Mines, Dhanbad.
6. Murthy, M.V.N., Mazumder, S.K. and Bhaumik, N. (1976): Significance of tectonic trends In the geological evolution of the Meghalaya uplands since Precambrian. Geol. Surv. India, Misc. Publ., No.23, pp.471-484.
7. Naidu PS 1972 Maximum likelihood (ML) estimation of depth from the spectrum of aeromagnetic fields; Pure and Appl. Geophysics., 95, 141-149.
8. NGRI.,(1978): Gravity map of India, Scale 1:5,000,000. National Geophysical Research Institute, Hyderabad.
9. Pathak, B., Syiem, S.M., Kalyan Mukherjee., and Chakrabortty, G.K., (2014): Gravity magnetic anomaly and its relation to seismotectonic-neotectonic features around Kopili valley area, Brahmaputra basin, Assam. Indian Journal of Geosciences, Vol.68, No.4, pp.401- 420.
10. Seno, T., and Rehman, H.U., (2011): When and why the continental crust is subducted: Examples of Hindu Kush and Burma. Gondwana Research 19, pp.327–333.
11. Spector A, and Grant FS 1970 Statistical models for interpreting aeromagnetic data; Geophysics. 35, 293.