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Hydrocarbon and Mineral Exploration in Abakaliki, South Eastern Nigeria

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ABSTRACT
Aeromagnetic data of Abakaliki in the Lower Benue Trough flown at an altitude of 80m with line spacing of 500m and cross tie line of 2km was used for this study. The data was made available in digital form on the scale of 1:50,000 by the Nigeria Geological Survey Agency (NGSA). The data was processed using computer software (Potent V4.10.3). Forward and Inverse modeling techniques were used in addition to spectral analysis. Three profiles were taken on the contour map and modeled. The results showed five intrusive bodies made up of granulites, pyrite, and basalt. The depths of the intrusives range from 2.4km-6.32km. Dolerite intrusives were mainly found at areas around Idemba-Iza, and Abba Omega at depths of 2.4km, 2.7km, and 3.6km respectively.

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I. INTRODUCTION

Magnetic surveying investigates the subsurface based on variations in the Earth's magnetic field that result from the magnetic properties of the underlying rocks. The studied area is located within and around Abakaliki area in Ebonyi state (Fig. 1). It is situated within the Lower Benue Trough and is bounded by latitudes 6^{o}N-$6^{o}30^{1}$N and longitudes 8^{O}E- 8^{0} 30^{1}E. The aerial extent covers 3080.25sq m. Abakaliki was chosen as the study area because it has a lot of potentials for hydrocarbon and minerals such as lead, zinc, silver, salt, limestone, and dolerite which form quarry that give economic power to Abakaliki people. The Abakaliki anticlinorium is flanked by two synclines one of which coincides with the Anambra valley while the other one passes through Afikpo. Nigeria is currently intensifying surveys in eight basins in the country with a view to opening frontier exploration for hydrocarbon mapping, and Abakaliki falls within the Anambra basin in the lower Benue Trough.

Geology of the Area

The sequence of events that led to the formation of the Benue Trough and its component units (Fig. 1) are well documented (Burke et al, 1975; Benkhelil, 1982, 1988; Nwachukwu, 1972; Olade, 1975; Ofoegbu, 1984, 1985; Onuoha and Ofoegbu, 1988). The lower Benue Trough is underlain by a thick sedimentary sequence deposited in the Cretaceous era. The sediments that occur in the Abakaliki Anticlinoriun belong to four geological formations: Awgu shale(Caniacian); Nkporo shale(Campanian); Eze-Aku shale(Turonian); and Asu River Group(Albian). The sedimentary sequences were affected by large scale tectonic activities which occurred in two phases and culminated in the folding of the sediments (Nwachukwu, 1972). The folding episode that took place during the Santonian strongly affected the development of Abakaliki Anticlinorium. The predominantly compressional nature of the fold that developed during this period is revealed by their asymmetry and the reversed faults associated with them. Benkhelil (1988) in a detailed report on the geology of the Abakaliki domain likened its geological development to that which occurs in a complete orogenic cycle including sedimentation, magmatism, metamorphism and compressive tectonics. The magmatism that occurred resulted in the injection of numerous intrusive bodies into the shales of Eze-Aku and Asu River Group. Intermediate intrusives outcropped in some parts of the study area, for example in Abakaliki town and also around Odomoke. These intrusives occur mainly as sills (Ofoegbu, 1985; Eze and Mamah, 1985).

Data source

Two sets of data were obtained as part of a nationwide aeromagnetic survey which was sponsored by the Nigerian Geological Survey Agency, (NGSA) in 1974 (Fig.2) and 2008 respectively. For the purpose of this study, we used the 2008 digital data. The data was digitized along flight lines and plotted with a contour interval of 2.5nT with average flight elevation of about 80m; and cross tie of 2km which helped in leveling the data. The data was made available in digital form on the scale of 1:50,000 shown as (Fig. 3).

Modeling of selected profiles:

Careful study of Fig.3 shows four sections of different anomalous patterns. On the right, is a region of igneous rocks and it occurs at NNW. Shallow intrusives are observed on the west and SSW. Middle of the map at Abakaliki and Idemba Iza are deep seated basalt/gabbro. Three (3) profiles were taken across the major anomalies for modeling as shown in (Fig.4). Forward and inverse modeling techniques were applied to model each profile various. Parameters of the bodies were varied in order to obtain a close match between the observed data and calculated data.

Profile A which cuts across Northeast and Southwest of the study area was modeled using four different bodies: sphere, ellipse, dyke and rectangular prism. The model revealed two intrusive bodies (dolerite) with susceptibilities 0.06 and 0.013 buried at depths of 3.4km and 4.7km respectively. Other bodies are granulites with susceptibility of 0.0002 buried at a depth of 3.5km and salt with susceptibility of -0.0001 buried at a depth of 4.6km. The crosses represent the observed field while the dotted line represents the model.

Profile B is a North-South profile. It was modeled with 3 bodies: two rectangular prisms and a dyke. The model revealed presence of 3 intrusive bodies (dolerite) with susceptibilities of 0.016, 0.010 and 0.010 each and buried at depths of 2.4km, 2.7km, and 3.6km respectively.

Profile C is also a North-South profile. It was modeled with 3 bodies: two ellipsoids and a rectangular prism. The model revealed one pyrite with susceptibility of 0.003 buried at a depth of 5.9km and two basic igneous intrusives with susceptibilities of 0.0279 and 0.0329 each, buried at depths of 6.32km and 5.9km respectively.

Figure 8. Shows spectral analysis of the data. It is obvious that sedimentary thickness is enough to host hydrocarbon. Above 10km, Curie temperature is quite high to allow accumulation of hydrocarbon.

Results and discussion

Anomalous bodies in Abakaliki area have been modeled using 2D/3D modeling software (Potent V4.10.3). The forward and inverse modeling applied on Profile A showed that depths to the anomalous bodies in the area range from 3.4km – 4.7km. It has two intrusives of susceptibility 0.01 each, one granulite with susceptibility of 0.0002 and one salt deposit of susceptibility -0.0001. Profile B showed a shallow depth which ranges from 2.4km -3.6km. It has three intrusive bodies with susceptibility of 0.01 each. Profile C showed a deeper depth which ranges from 5.9km - 6.3km. Anomalies in this area revealed basic igneous intrusives which are in the basement complex and their susceptibilities ranged from 0.0279 -0.0326. Profile A cuts across Abakaliki town and it revealed two intrusives, granulites and salt with spherical, ellipsoidal, dyke-like and rectangular prism shapes respectively. The shape of theses bodies are delineated by A (width), B (length) and C (height). From these values the volume and area of these bodies can be calculated. Profile B passed through Abba Omega and Idemba –Iza and it revealed three intrusives with two rectangular prisms and dyke-like shapes respectively. Profile C cuts across Mfuma and it revealed one pyrite and igneous basement with two ellipsoidal and rectangular prism-like shapes.

CONCLUSION:

Aeromagnetic data from Abakaliki has been analysed. The result of the analysis showed that there are intrusive bodies (dolerite sills) around Abba Omega and Idemba – Iza and intrusive rocks (basic igneous) which correlate well with the work of Ofoegbu (1985), and Obi et. al., (2010). There is also availability of mineral (pyrite), granulites and salt at Mfuma which corroborates the work of Ehinola (2010). The major source of the magnetic anomalies in Abakaliki arises from the presence of intrusives and basic igneous in the sedimentary terrain. Ofoegbu and Onuoha, (1991) used spectral analysis on aeromagnetic data of Abakaliki and estimated a shallow sediment thickness which varies between 1.2km and 2.5km. In our study the spectral analysis indicates maximum depths of 4.96km to 9.8km with minimum ranging from 0.12km to 0.71km. We agree with obi et. al (2010) who concluded that hydrocarbon potential in Abakaliki is a possibility. Our depths from modeling and spectral analysis are more reliable because of 2D/3D. Estimation of quantity and size.

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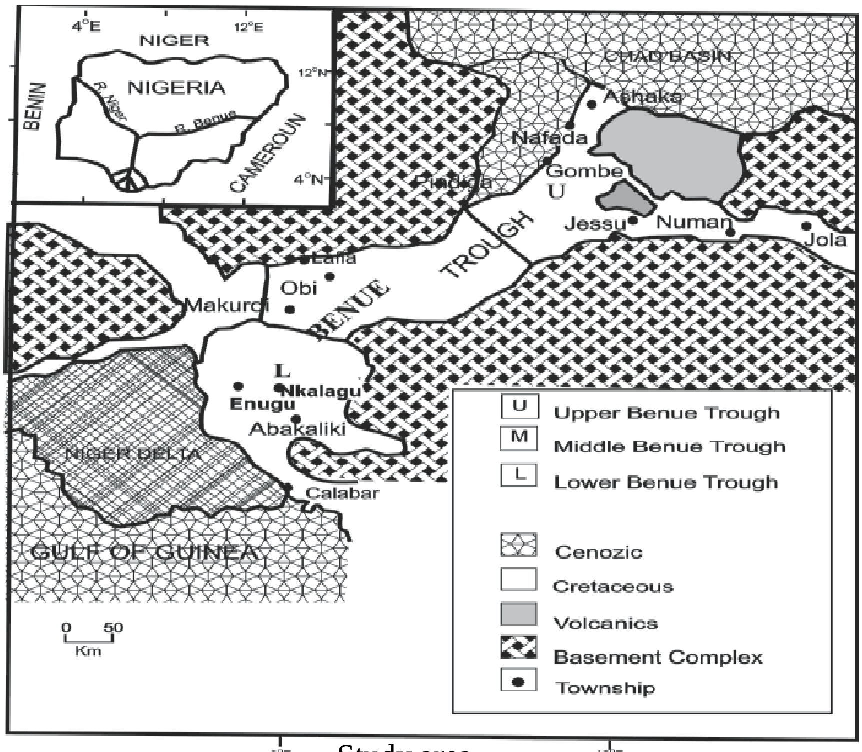


Study area

Fig. 1. Geology map of Benue Trough (Peters, 1982)

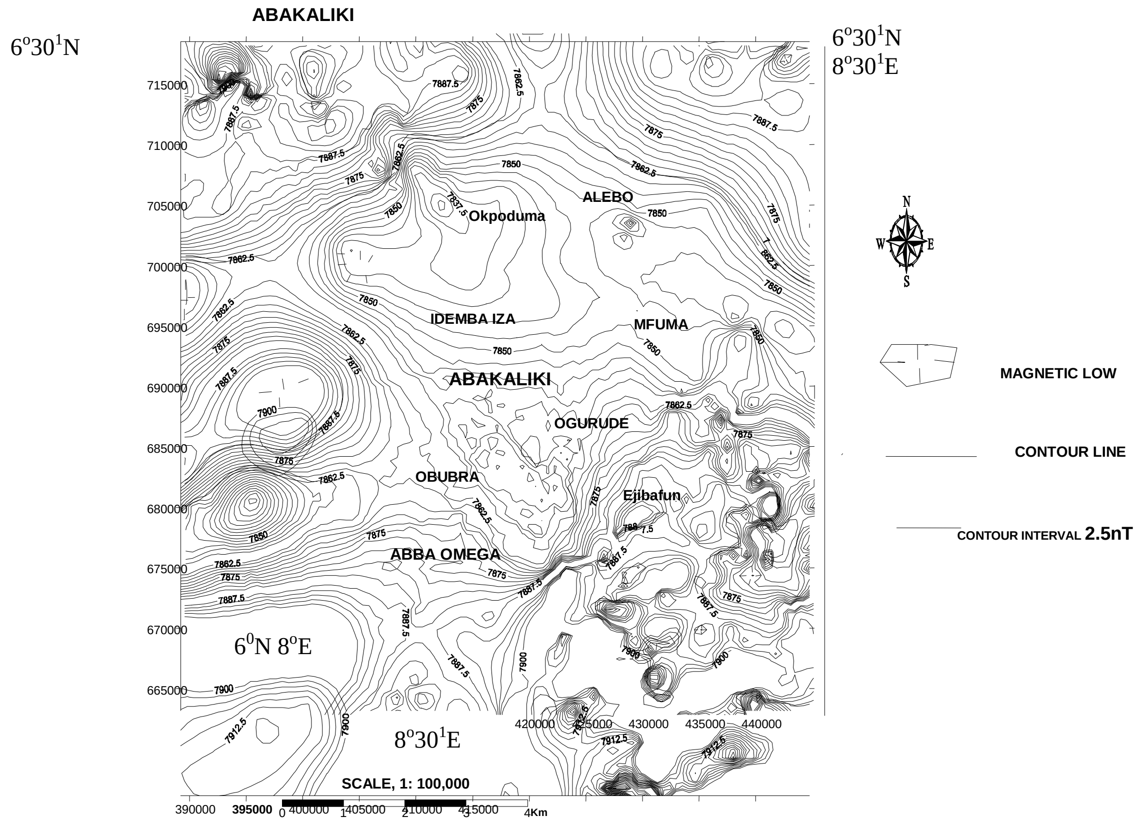


Fig. 2. Sheet 303, Abakaliki aeromagnetic contour map (1974, source NGSA)

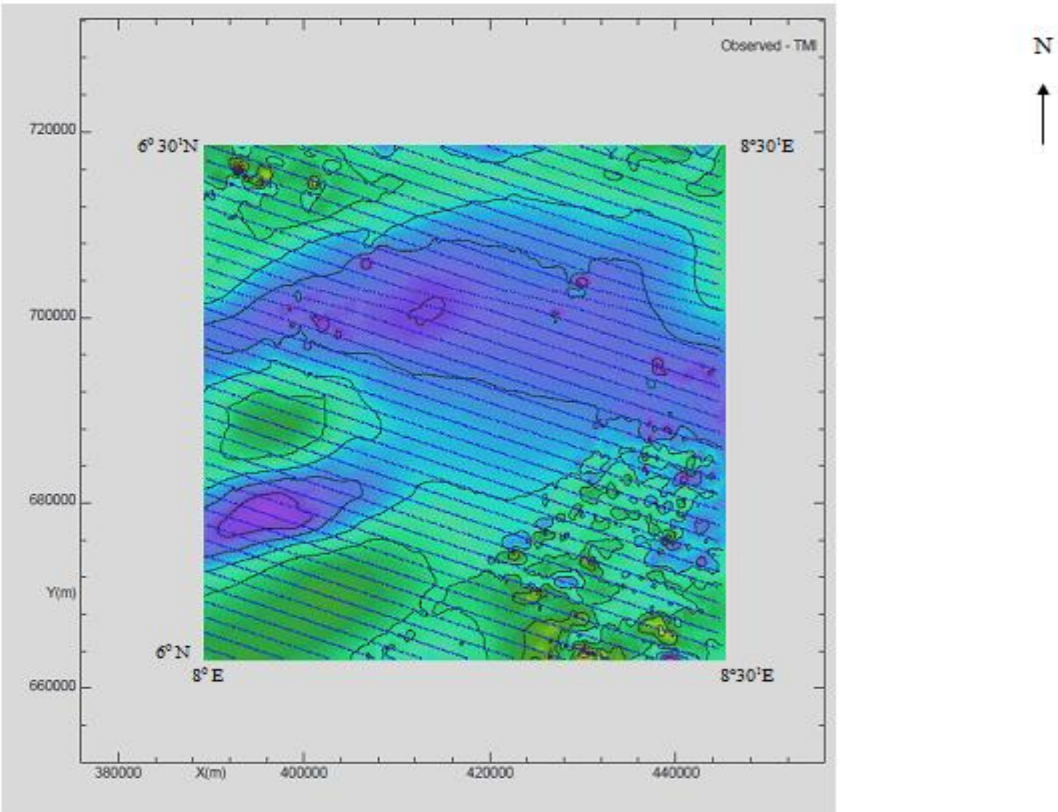


Fig.3. 2008 Aeromagnetic contoured map of Abakaliki (Source NGSA)

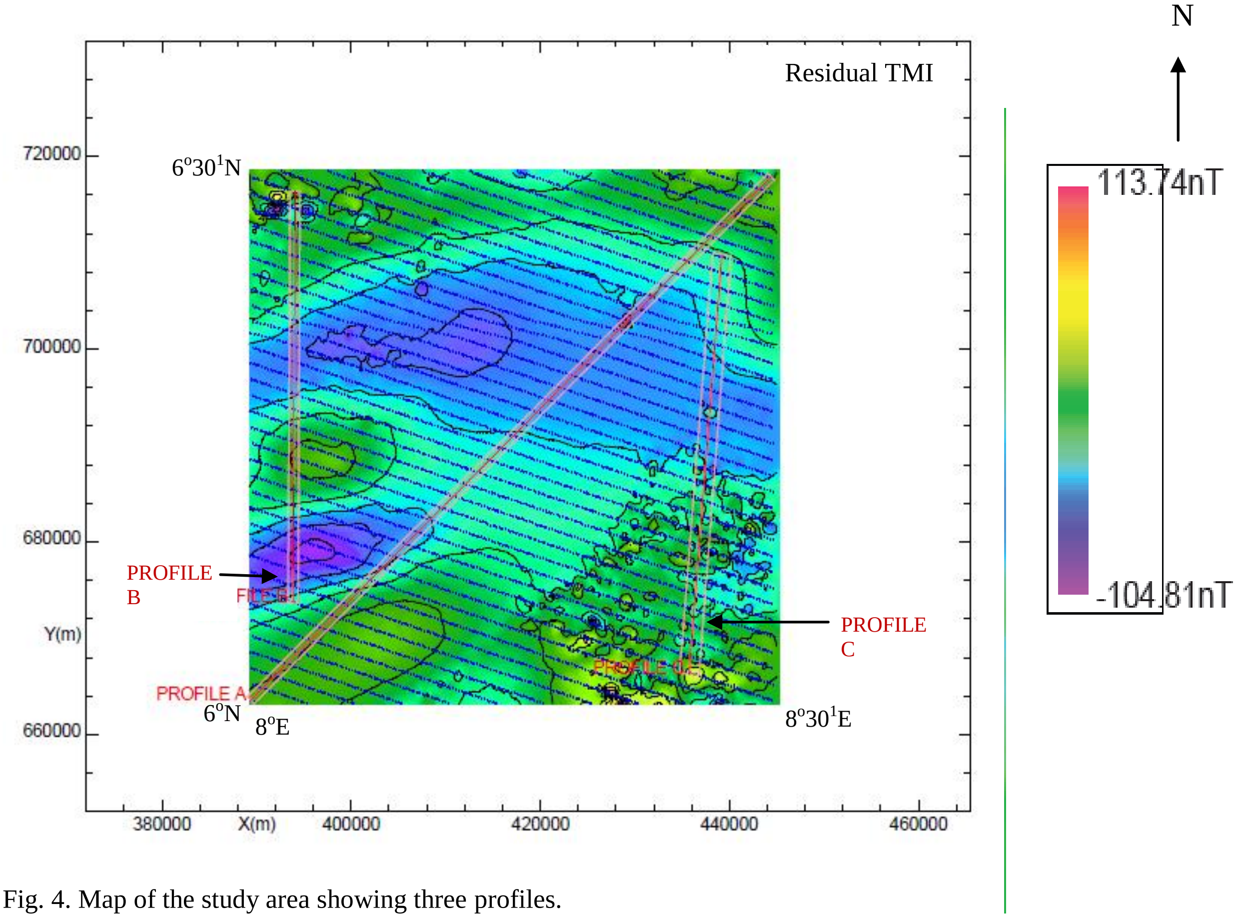


Fig. 4. Map of the study area showing three profiles.

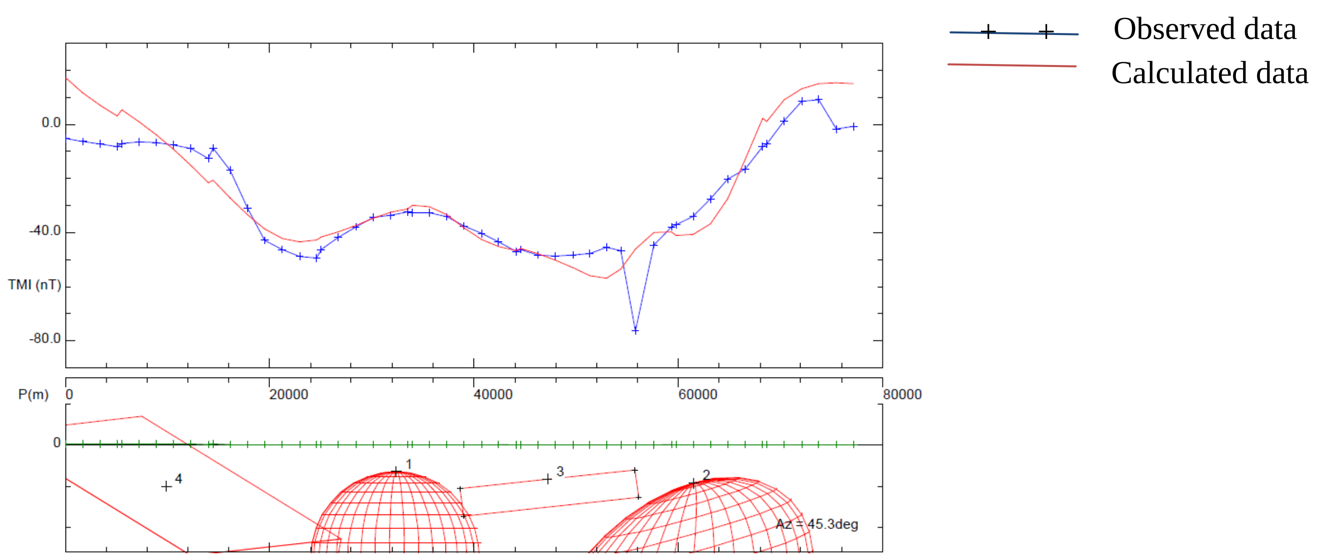


Fig.5. Modeled profile A

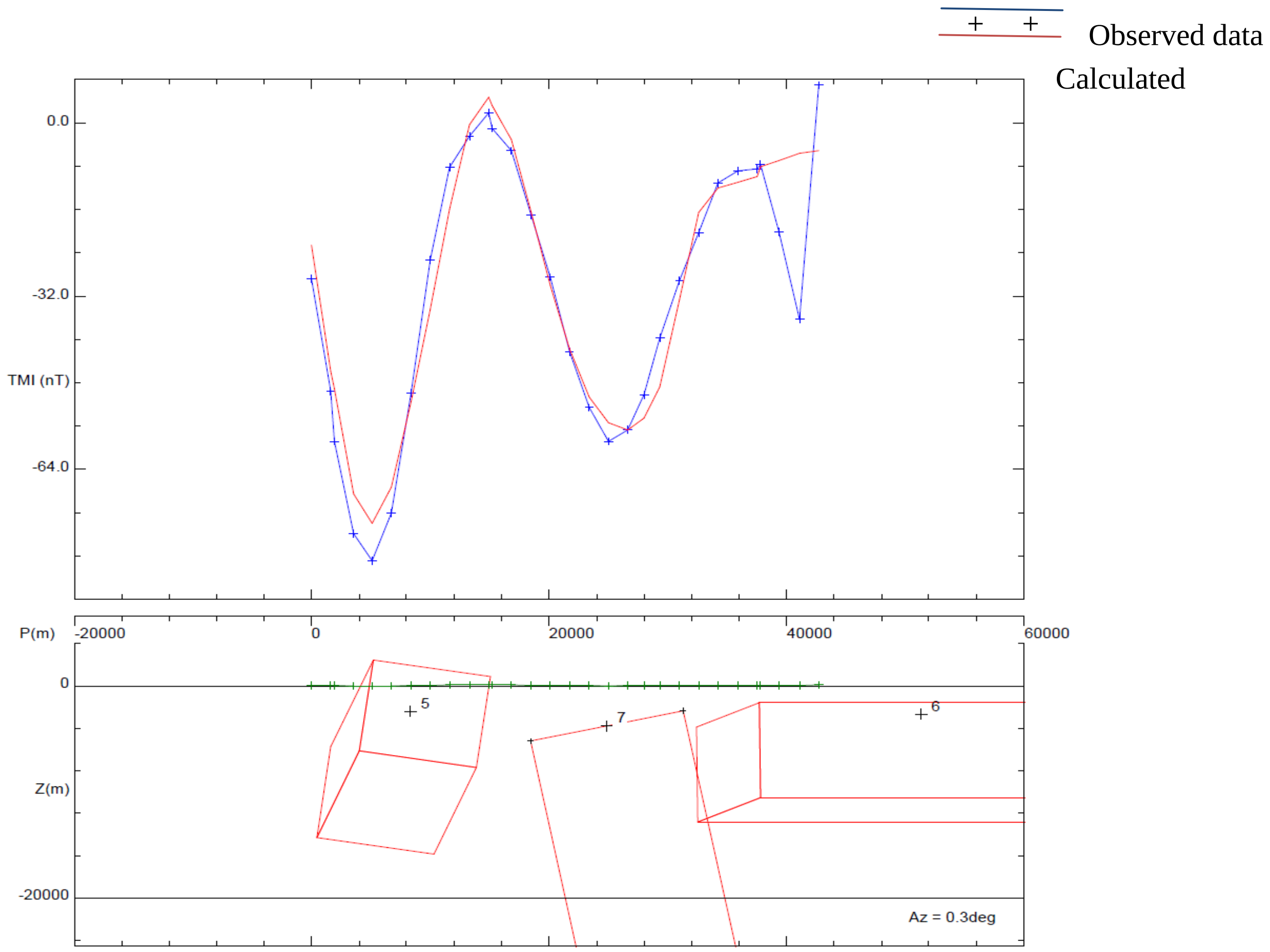


Fig.6. Modeled profile B

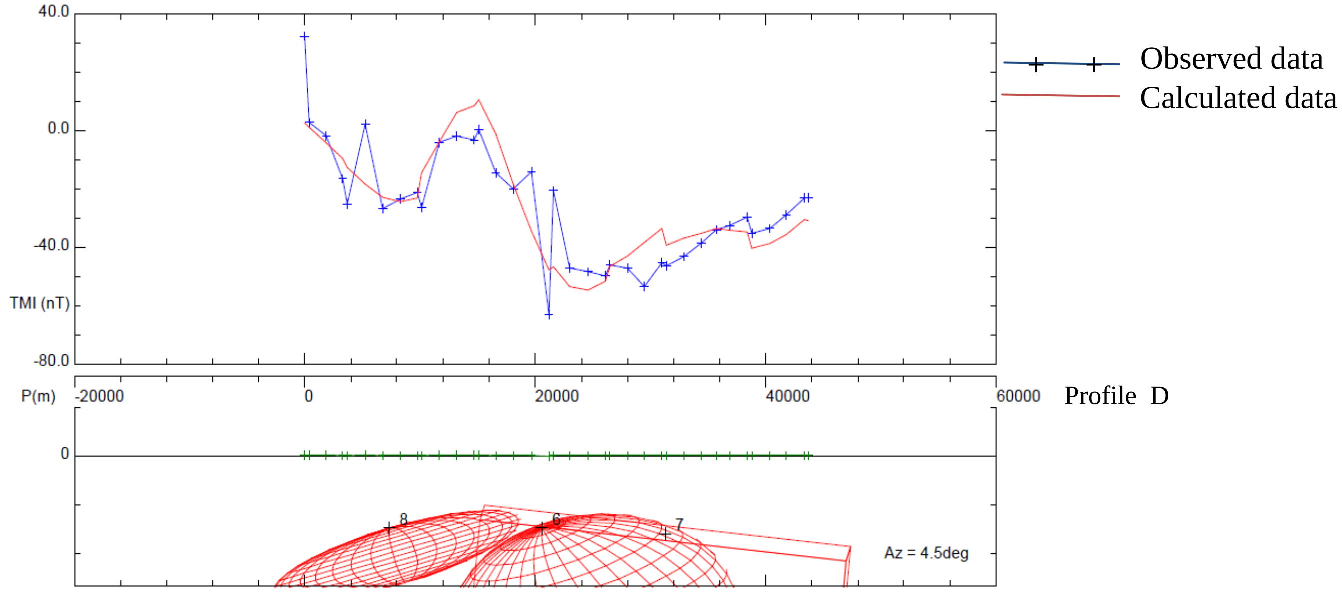
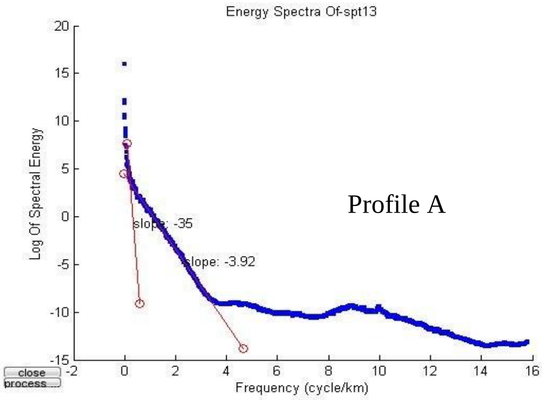
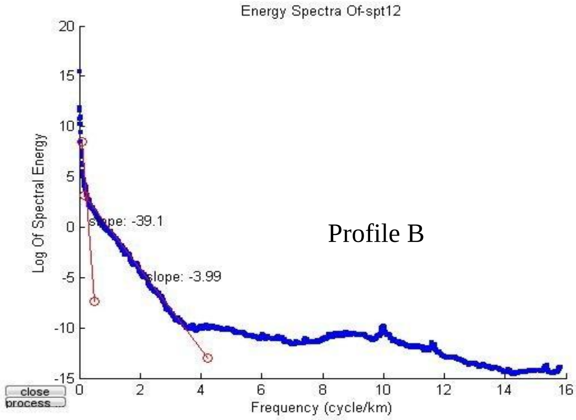


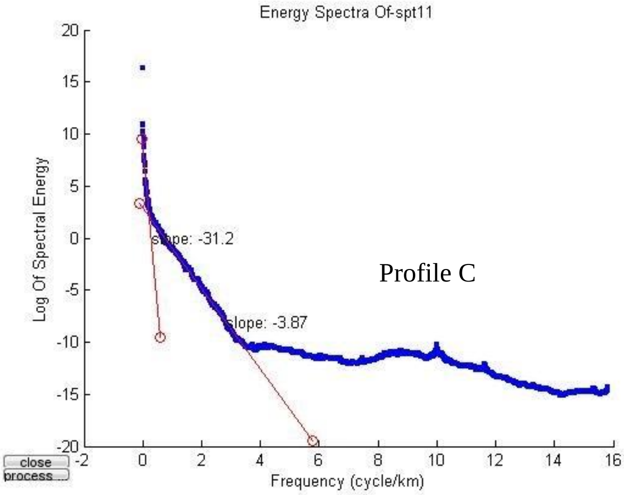
Fig.7. Modeled profile C



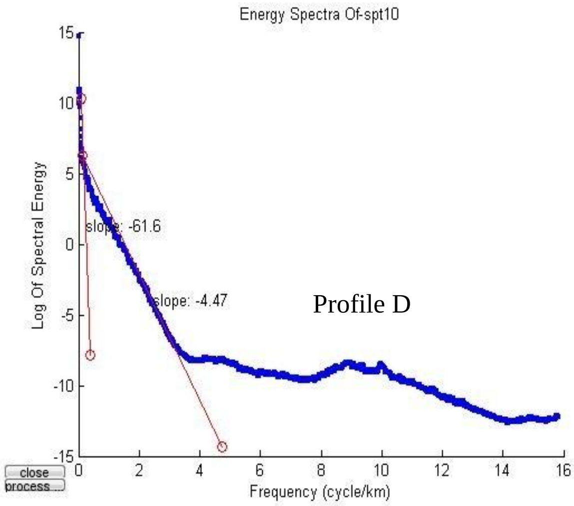
Spectral at long. $8^0 15^1$E - $8^0 30^1$E lat. 6^0N - $6^0 30^1$N
Depth 1 = 5.57km, Depth 2 = 0.62km



Spectral at long. 8^0E - $8^0 15^1$E lat 6^0N - $6^0 30^1$N
Depth 1 = 6.22km, Depth 2 = 0.63km



Spectral at long.8^0E - $8^0 30^1$E lat. $6^0 15^1$N - $6^0 30^1$N
Depth 1= 4.96km, Depth 2 = 0.62km



Spectral at long. 8^0E - $8^0 30^1$E lat. 6^0N - $6^0 15^1$N
Depth 1 = 9.80km, Depth 2 = 0.71km

Fig. 8. **Abakaliki Spectral Analysis**