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Basinal Configuration And Intrasediment Intrusives As Revealed By Aeromagnetics Data Of South East Sector Of Mamfe Basin, Nigeria.

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Abstract: *Five aeromagnetic maps on a scale of 1:100,000 were analysed using the horizontal gradient magnitude and 2.5D forward modeling method in the South east Sector of mamfe basin Nigeria. The data was manually digitized and filtered using polynomial fitting method to obtain a residual map, reduction to the pole was done after map merging prior to filtering. The HDep and Saki softwares were used in determining the sediments thickness, types of intrusive, and basin configuration. The results identified (17) seventeen intrusives and the basin configuration made of horst and graben structures, the sediment thickness from both methods range between 0.5km–4.3km, the areas with the highest accumulation of sediments (2.6km – 4.3km) is within Edor area in Bansara, these area also has three major intrusives which may serve as a source of heat for thermal maturation or over maturation of these sediments.*
Keywords*: configuration,forward modeling, polynomial fitting*

I. Introduction

The South eastern Mamfe basin is a sedimentary basin that border Cross River State in Nigeria and South Western Cameroon. The present study is restricted to the Nigeria sector of the Mamfe basin which extents from latitude 5^0 30^1-6^0 30 'N and longitude $8^0.00^1$–9^0 30^1 E.-(fig1). The determination of sediments thickness, types of intrusives, and basin configuration was done with the use of several suites of potential field softwares from the united state geological surveys (USGS).

Tectonic Setting

The South east Nigerian sector of mamfe basin is a segment of the lower Benue trough which is a linear intracratonic graben trending NE-SW. It's origin is associated with the separation of Africa and South American Continent in the early cretaceous. Reviews on the geology of the trough have been presented by several workers (eg. Petters, 1982; Obaje, 1994; Alkande and Erdman, 1998, Chiadiobi, 2010). Also previous geophysical surveys over the Benue trough reveal a crustal thinning beneath the Benue trough, (Ajakaiye, 1981; Adighije, 1979; Ofoegbu, 1995; and Okereke, 1984) flanked on both sides by linear sub-basins.

The mamfe sub-basin forms part of the lower Benue trough which is surrounded by Oban massif that extend to the Obudu Plateau, which stretches to form part of the Bamenda massif in Cameroon republic.
The rift system which forms the lower Benue trough had several episodes of folding of the sediments which were deposited structurally in three segments from massif to cenomanian, these sediment accumulation form's part of the mamfe sub –basin deposits.

Geology

The oldest sedimentary rocks in the study area is the Asu river group (Albian) which comprise of sandstone, shales and lime stones, these sediments lies unconformably on the precambrain basement (granites, and biotite gnesses). Overlying the Asu river group is the Eze-Aku formation (Turonian) which comprise of shales and their lateral equivalents of Agwu formation (mode, 1997). These sedimentary rocks lies unconformably on the Asu river group, the new Basalts (tertiary) are latter emplacements within these cretaceous sediments (Fig. 2).

Theoritical Background

Horizontal gradient magnitude: This method is a simple approach to estimating contact locations and depth (Phillips 1997, Blakely and Simpson, 1986). If m (x,y) is the magnetic field and $\frac{dm}{dx}$ and $\frac{dm}{dy}$ are derivatives in the x – and – y directions, then the horizontal gradient magnitude HGM (x,y) is given by:

$$HGM\ (x,y) = \sqrt{\left[\frac{dm}{dx}\right]^2 + \left(\frac{dm}{dy}\right)^2} \ldots\ldots\ldots\ldots\ldots equ\ (1)$$

This function peaks over magnetic contacts under the following assumption (i), the regional magnetic field is vertical (ii) contacts are vertical (iii) sources are thick, these assumptions may break down in practice, but the approach remains the least susceptible to noise in the data because it only requires the calculations of the two first order horizontal derivatives of the magnetic field. Generally, the theoretical shape of the horizontal gradient magnitude over a contact is given by

$$HGM = \frac{K}{h^2 + d^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots equ.\ (2)$$

Where he is the horizontal distance to the contact, d = depth to the top of the contact and k = a constant. Due to the assumptions of thick sources, the depth estimate made using this procedure represent minimum depths (Olagundoye 2004, Phillip's 1997, Pilkinglon & Kealing 2006).

Modeling: Modeling may be defined as a process from which one tries to deduce effect of comparison to observations with the aim of developing a better understanding of the observations. Forward magnetic modeling is the art of estimating the geometry of the magnetic source or distribution of magnetization with the source by trial – and – error (Dobrin & Sarvit 1988). Forward modeling is a quantitative approach that involves making numerical estimates of the depth and dimension of sources (Reeves, 2005) most times the model parameter are adjusted in other to obtain a better agreement between observed and calculated anomalies.

II. Data Analysis

Five aeromagnetic total intensity field maps on a scale of 1:100,000 were acquired from the Geological survey agency, Kaduna. The survey was conducted along E-W profiles with flight line spacing of 2.0 km and a tie line spacing of 20.0km and a flight elevation of 0.5216km above sea level (Table 1.)

The geomagnetic gradient was removed using the international geomagnetic reference field (I. G. R. F) formula of first January 1974. The mangnetic maps were digitaized at 1.0 km to avoid the problem of frequency alaizing, further processing of the data was done with the use of the United State Geological Services potential field software version 2.0. The software package has suites of programmes (A2xY2), PZGRD, GEOCON, HDEP, SURFIT, MFNIT, MFFILTER, MFEDSIGN, SAKI, JMEGER, FRTP and P< contour).

All the digntized data was manually done by extracting the coordinates of x and y at discrete point intervals along flight lines and their respective Z value for total field intensively determined. The A2xY2 Software was used in converting the data from binary to ascii and the P2GRD and J merger softwares used to grid and map-merge the data set. The merged data was contoured using Geocon and Pc –contour software to produce the total magnetic field map of the study area (fig. 3). Reduction to pole was done using FR-TP software where individual anomalies were properly centered prior to data filtering.

The reduced to the pole data was filtering using the polynomial filling method where the sufit software was used to obtain the residual after the regional was subtracted from the observed data, the P-C contour software was then used to contour the residual data to obtain the residual map of the study area (fig.4). Further analysis in determining depth to magnetic sources and basin configuration were made using HDEP and Saki softwares.

The output of the residual data was used in modeling the structure of the subsurface, this data was also used in HDEP software for determining the horizontal gradient magnitude for depth to source of magnetic basement solutions. The output of HDEP generated 180 solutions points to generate the horizontal gradient magnitude map contoured using surfer 7.0 (fig. 5). The forward modeling was done along profile lines choosen perpendicular to major magnetic anomalies, the Saki software was used for this modeling, the residual data was used as input, the process requires generation of an observed plot from the input data and a calculated plot generated through imput of various parameters such as total field Azimuth, inclination, declination, and no of bodies, no of vertices (Table 2)These parameters are changed until a perfect match is obtained between the observed and calculated output with a minimum percentage error of < 5% (Phillips 1997, Obi et al 2008, Olagudoye 2004). Five profiles were modeled and the output of the modeled results are shown in figures 6, 7, 8, 9, 10, and table 2.0.

III. Results

The residual map (fig.4) has five model profile lines which were carefully choosen across major magnetic anomalies and the results obtained from the model profiles are compared with those obtained from the horizontal gradient magnitude (fig.5).

Depth to magnetic source using the horizontal gradient magnitude (HGM) shows that the bansara area ranges between 3.5km-4.1km, and saki model depth of 2.0-2.6km (fig.5), these area has the highest depth range in the study area. The Abakalilli area has HGM depth of 1.5km– 2.5km with saki model depths ranging 1.0km - 2.3km (fig. 5,7), Ikom area has HGM depths ranging between 1.5km–2.2km with saki model depth ranging between 0.5-1.5km (fig. 5,8). The adjacent Umaji area has HGM depths ranging between 1.7-2.1km with saki model depths ranging between 0.5-1.0km (fig 5, 9). Also the Ugep area has HGM depths ranging between 1.5-2.5km with saki model depths ranging between 0.5-1.1km (Fig 5, 10).

The saki models (fig 6, 7,8,9,10) were constrained by different parameters as listed above, the forward models reveal different types of intrusive (table 2). A total of (17) seventeen intrusive were encountered at different locations of the study area. The Umaji and Ikom area has basaltic intrusive while gneisses and Rhyolites dominated other areas (Table 2.)

IV. Disscussion / Conclusion

The area around Ikom and its surrounding environs of Ugep, Bansara and Abakaliki has been studied using the horizontal gradient magnitude method for source to magnetic basement determination, and forward modeling for subsurface basin configuration. The result of depth to magnetic basement using both the HGM and saki forward modeling are well collobrated indicating areas of uplifts (Horst) averaging 0.5km-2.0km and depression (Grabens) 2.5 – 4.1km.

The Bansara area has the highest depth of sediment accumulation reaching depths 4.1km. The sediment Thickness decreased towards the Umaji area 0.5km, Ikom area 1.0-2.0km and Ugep area 1.1-1.5km. Also, the Bansara (Edor) areas is the adjacent basin towards Ogoja from the Aballaliki uplifted areas with depth reaching 0.8km – 2.3km

The shallow depth area of Umaji, Ikom and Ugep has (12) twelve intrusives, usually the area is less favourable for hydrocarbon exploration activities. However the area around Bansara (Mfum) which has sediments thickness about 4.1km has three intrusives whose presence may serve as a source of heat for thermal maturation or over maturation of these sediments, this area remain the most favourable area for hydrocarbon prospecting within the mamfe basin. The numerous presence of basaltic intrusive and the shallow depths of sediments within Ikom Umaji, and Ugep make the areas less favourable for hydrocarbon exploration activities.

Conclusively, exploration for hydrocarbon activities in the Nigerian sector of the mamfe basin should be concentrated in the Mfum-Edor areas of Bansara.

S/N	Sheet Name	Sheet Number	Flight line Direction (degree)	Fight line Spacing (km)	Tie line Spacing (km)	Flight altitude (km)
1	Ikom	315	150/330	2	20	500
2	Abakaliki	303	50/330	2	20	500
3	Bansara	304	150/330	2	20	500
4	Mukuru	305	150/330	2	20	500
5	Ugep	314	150/330	2	20	500

Table 1.0 Flight line parameter

Profile name	**Declination**	**Declination**	**Azimuth**	**Total field (NT)**	**No of Instrusives**	**No of vertex**	**No of bodied**	**Dept. sediments**	**Susceptibilities of intrusives**	**Types of intrusive**	**RMS %**	**Profile length (km)**
Abakaliki	127^0	6.0	173^0	32535	2	44	9	08-2.3	0.0035 0.0025	Gneiss/Ryolite	1.0	20.6
Bansara	-	-	126.5^0	-	3	29	7	1.5-2.6	0.0025 0.0025 0.0085	Gneiss/Ryolite	1.5	21.6
Umaji	-	-	85^0	-	6	44	10	0.5-1.0	0.0025 0.015 0.015 0.0085 0.0045 0.0025	Gneiss/Ryolite Basalt Basalt Gneiss/Ryolite Gneiss/Ryolite Gneiss/Ryolite	1.2	13.8
Ikom	-	-	85^0	-	2	31	7	0.5-1.5	0.015 0.0025	Basalt Gneiss/Ry	1.5	15.8

										olite		
Ugep	-	-	76^0	-	4	35	13	0.5-1.0	0.025 0.025	Gneiss/Ry olite Gneiss/Ry olite	1.5	23.2

Table 2.0 Summary of modeled profile / statistics

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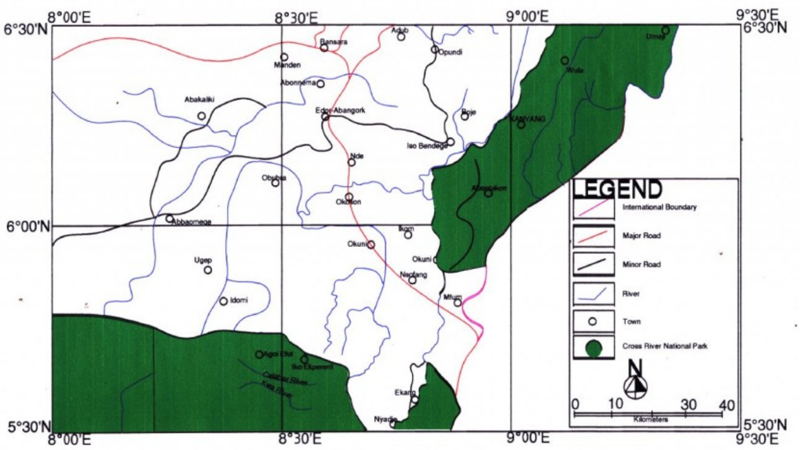


Fig.1 Location map of the study area

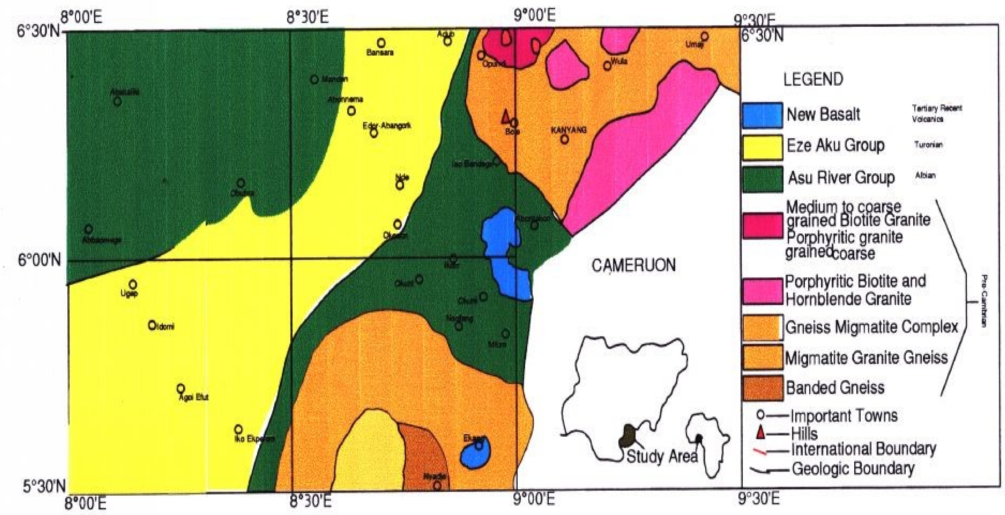


Fig.2 Geologic Map of the study area

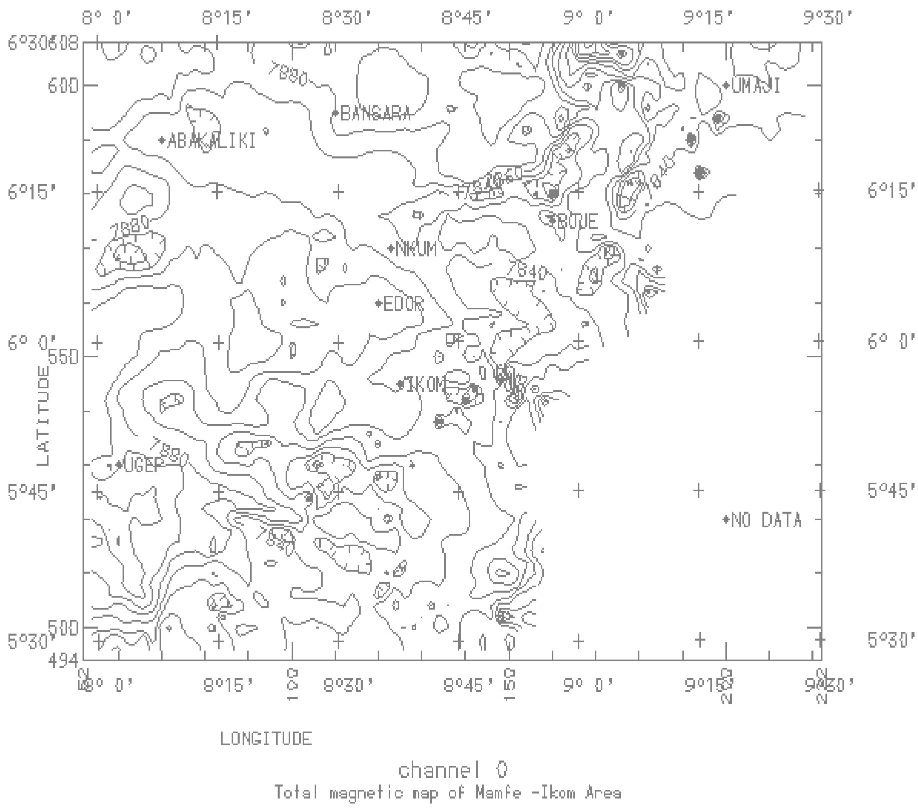


Fig.3 Total Magnetic Field Intensity Map of the study area

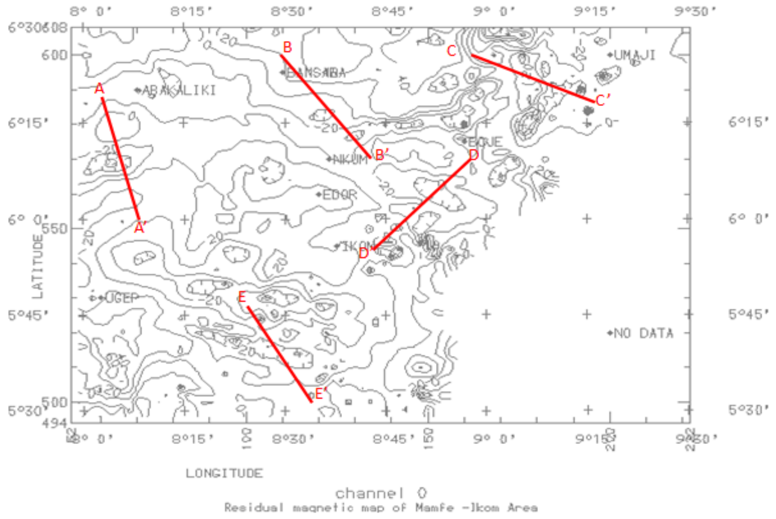


Fig. 4: Residual magnetic map of Mamfe-Ikom Area

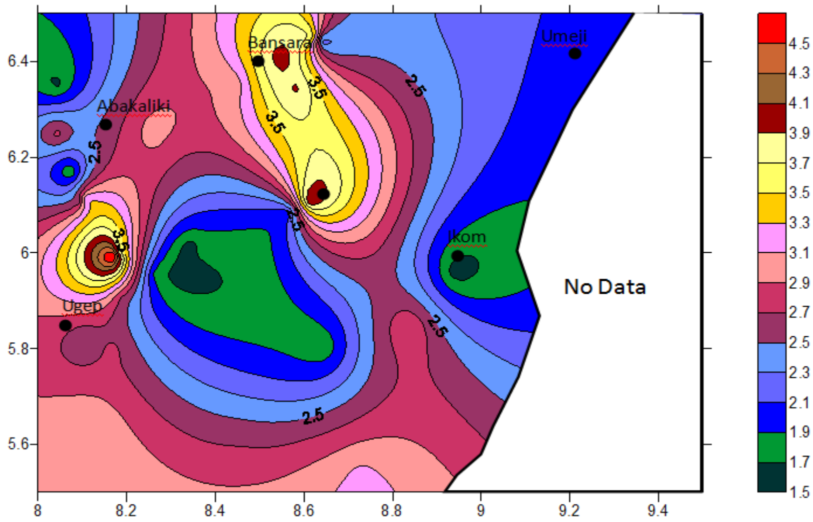


Fig. 5: Horizontal gradient magnitude depth Mamfe-Basin

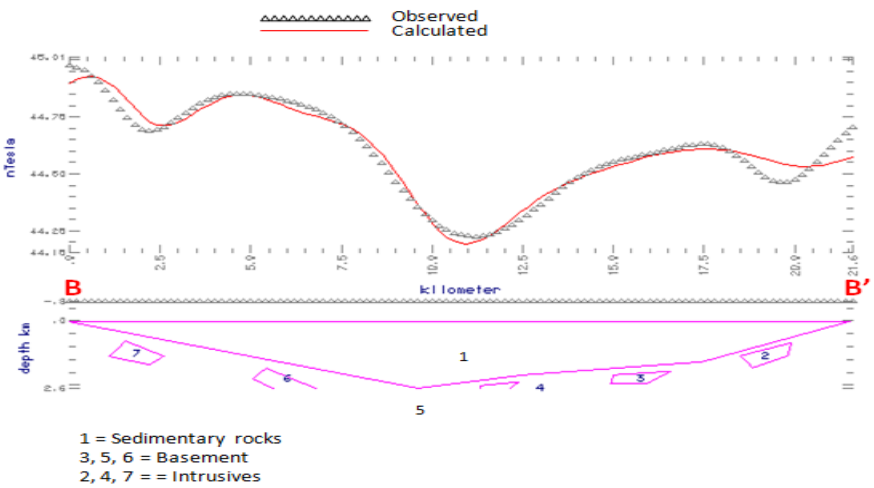
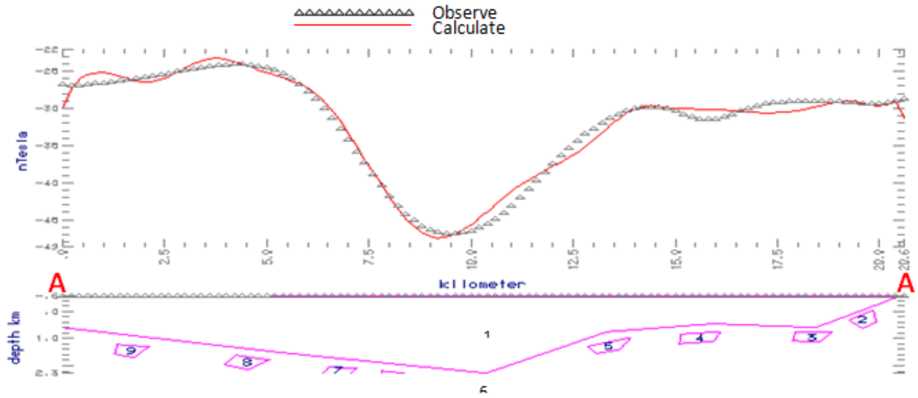
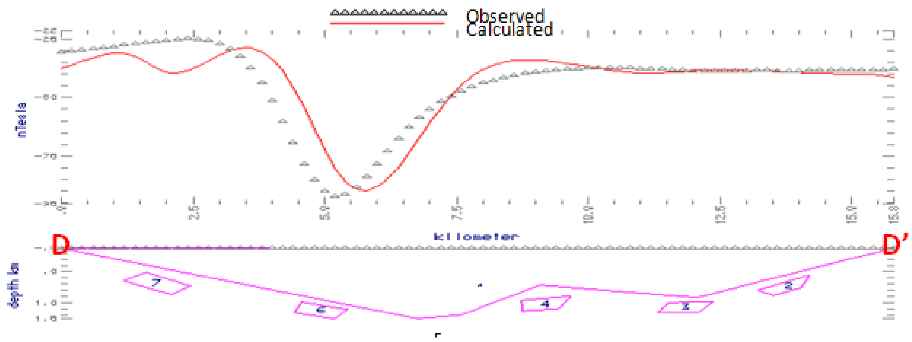


Fig. 6: Bansara model



1 = Sedimentary rocks
2, 3, 4, 5, 8, 9 =
Basement

Fig. 7: Saki model plot of



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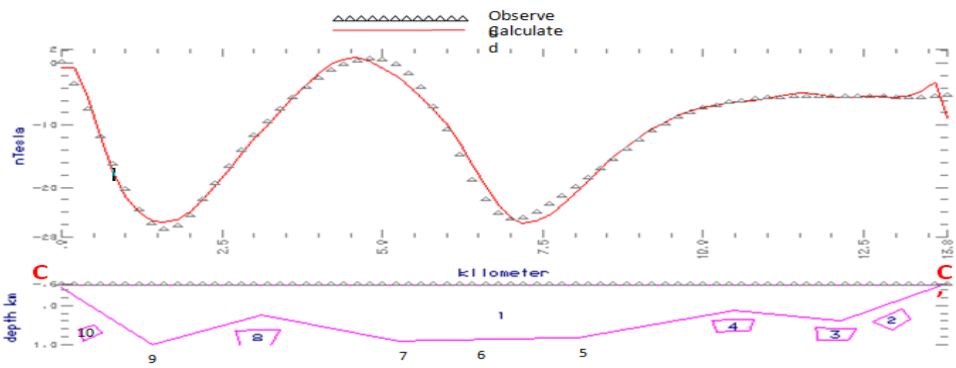
2, 3, 4, 7 = Basement
5, 6 = Intrusives

Fig. 8: Saki model plot of Ikom



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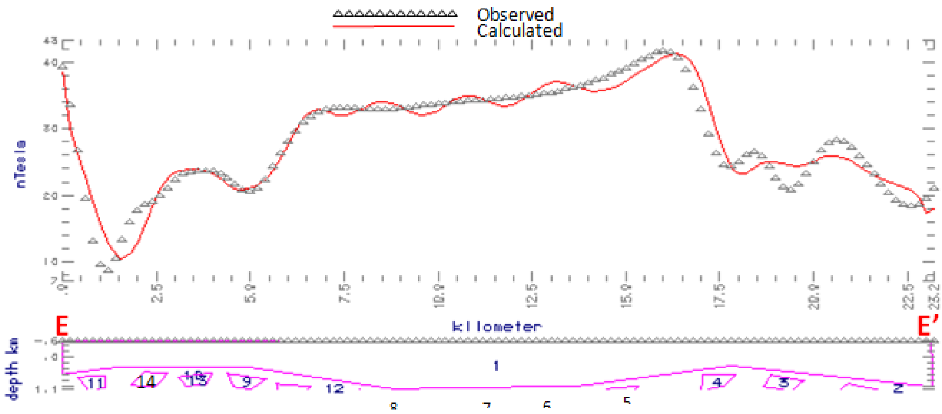
2, 3, 4 = Basement
5, 6, 7, 8, 9, 10 = =
Intrusives

Fig. 9: Saki model plot of Umaji



1 = Sedimentary rocks
14, 5, 6, 7, 8, 9, 10, 11, 12 = Basement
3, 13 = Intrusives

Fig. 10: Saki model plot of Ugep