2D-INVERSION OF GROUND MAGNETIC DATA ACQUIRED AROUND THE SCHIST BELT AREAS OF KANO STATE, NIGERIA FOR ESTIMATION OF CAUSATIVE BODY PARAMETERS

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Abstract: This paper seeks to model the ground magnetic field data acquired around the Schist belt areas of Kano State in order to extract the causative body parameters. The only parameter estimated from previous work using the same data, is the depth to the causative body and hence the need to estimate other parameters. Six profiles cutting through both high and low anomalous zones were drawn on the residual map; mag2DC software was used to model the data. The parameters obtained from the modeling include body center, maximum width, depth-to-body, depth extent and susceptibility, with their values ranging from 50.94 m to 606.57 m, 4.48 m to 200.72 m, 7.46 m to 150.75 m, 82.09 m to 465.61 m and -0.0879 to 0.1043, respectively. The value for depth-to-body from this work was compared with those of previous works and found to agree fairly well. The susceptibility values suggest that the study area comprises of iron and chromium rich minerals as well as quartz. It is recommended that geochemical analysis should be carried out on rock samples in the study area to ascertain the actual minerals present.

Keywords: Causative body parameter, Mag2DC, Schist and 2-D inversion

Introduction

Magnetic method has been successfully used over the years by geophysicists/geologists for mineral prospecting (Biswas, 2018). This is due to the fact that minerals and rocks have magnetic susceptibilities thereby causing disturbances in the earth's magnetic field. These disturbances often referred to as anomalies, are analyzed and interpreted to gain information about the subsurface with regard to the mineral content (Shehu *et al.,* 2019). The parameters of the disturbing or causative bodies in the subsurface areimportant information in interpretation of the anomalies.

The depth to the body, its depth extent, its dimension and its magnetic susceptibility are parameters needed to be known for adequate interpretation. These parameters are usually not estimated using one particular method. For instance, depth estimation techniques such as Euler deconvolution or Source Parameter Imaging (SPI) give good estimate of depth of the causative body but may not give us information about the body's depth extent or its susceptibility. Many researchers have designed algorithms for modeling magnetic field data in order to obtain causative parameters. Examples of such works include Lelievre and Oldenburg (2006), Stucco *et al.* (2009), Cooper (2015), Di Maio *et al*. (2020) and others.

Mag2DC software for windows, developed based on the work of Cooper (2015), allows the forward modeling and inversion of magnetic data with a great amount of ease. It involves a trial and error process to place the best fit to the observed anomalies thereby extracting the parameters of the bodies causing the anomalies. It requires a startup parameter before progressing to extract other parameters. The bodies making up the model have their susceptibility values displayed on them with cold colors representing low values and high colors representing high values. The software has been successfully used by researchers for example Waswa *et al.* (2015), Seurey *et al.* (2016) and a few others.

The Schist belt parts of Kano State are an area where few geophysical works relating to solid minerals prospecting have been carried out namely, Bagare *et al.* (2018), Shehu *et al.* (2019a) and Shehu *et al.* (2019b). A recent study (Shehu *et al.*, 2021) done in the area (longitudes 7º 58' 23'' E to 7º 59' 10'' E and latitudes 12º 6' 26'' N to 12º 7' 3'' N covering approximately 1.3 by 1 km^2) used ground magnetic data to estimate depth to magnetic source bodies using Euler deconvolution technique. However the work did not give information on other source body parameters.

This paper therefore, seeks to give information about the causative body parameters namely, depth to body, depth extent of body, body dimension as well as susceptibility by carrying out a 2-D inversion of the ground magnetic data measured by Shehu *et al.* (2021) using mag2DC software package.

Materials and Method

Materials

The materials used for the studies are

i. Ground magnetic data from Shehu *et al.* (2021): this include the Total Magnetic Intensity (TMI) and residual field maps shown in Figs. 1 and 2.
ii. Surfer 11 Software
iii. Mag2DC Software

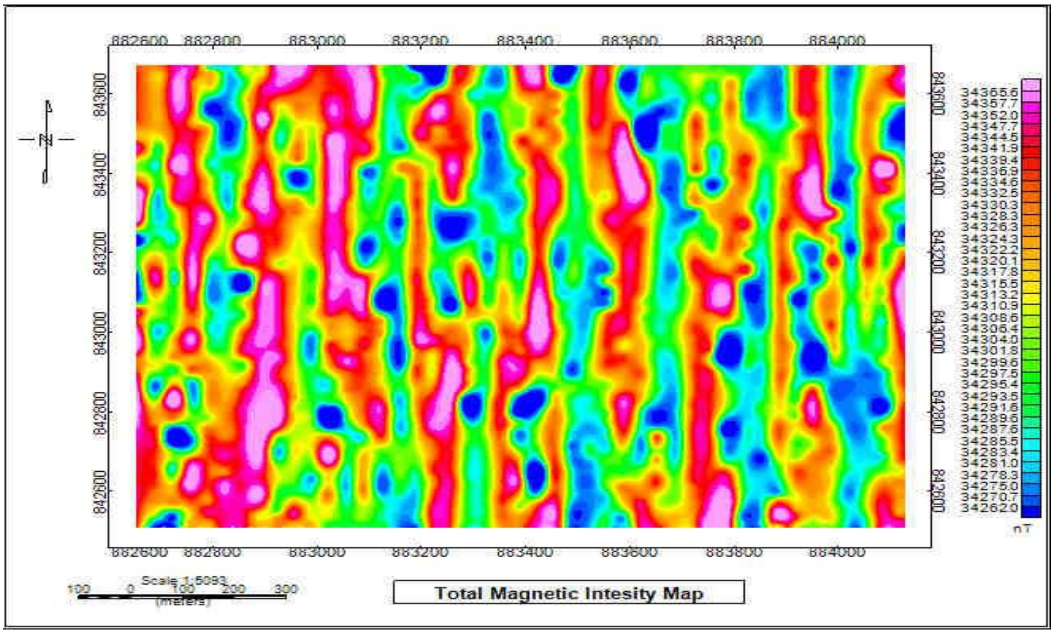

Fig. 1: Total Magnetic Intensity (TMI) Map of the Study Area (Shehu *et al.*, 2021)

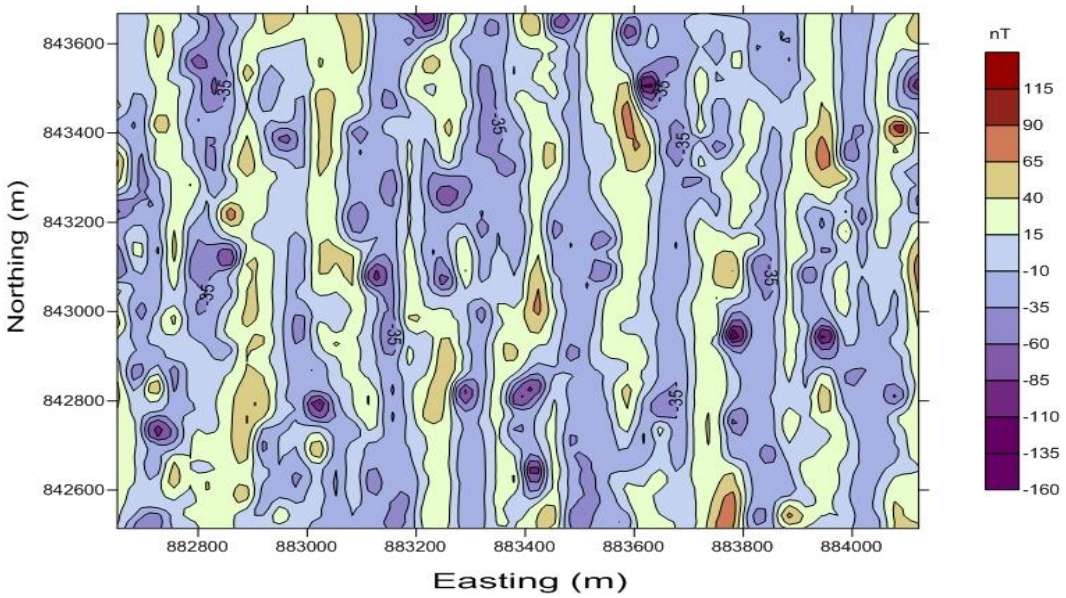

Fig. 2: Residual Field Map contoured 25 nT interval (Shehu *et al.*, 2021)

Method

Six (6) anomalous points across the residual field map obtained from Shehu *et al.* (2021) were selected and profiles were drawn across them using Surfer 11 Software. These points were then modeled using Mag2DC Software to extract the parameters of the causative bodies. Depth estimate i.e. 26.6 m (Shehu *et al.*, 2021) determined from Euler deconvolution technique was used as a startup parameter in the software.

Results and Discussion

Here, the results of the analyses carried out and discussions are presented.

Figure 3 shows the residual map with profiles drawn at different locations of the study area. The profiles are named AA', BB', CC', DD' EE' and FF' cutting across both high and low anomalous points to give a good representation of the study area. The location of the profiles is presented in Table 1.

Table 1: Profile names and their locations

S/N	Profile	Easting (m)	Northing (m)	Latitude in Degrees	Longitude in Degrees
1	A	883723.7	842976.7	12.476100	7.608772
2	A'	884022.6	842913.4	12.478800	7.608178
3	B	883531.3	843364.2	12.474380	7.612285
4	B'	883675.6	843592.1	12.475710	7.614332
5	C	883414.8	842571.5	12.473270	7.605135
6	C'	883417.3	843255.3	12.473340	7.611310
7	D	882685.4	842728.5	12.466680	7.606606
8	D'	883065.3	842801.9	12.470130	7.607241
9	E	882677.8	843131.2	12.466640	7.610243
10	E'	882898.1	843242.6	12.468640	7.611233
11	F	883898.5	843338.9	12.477700	7.612030
12	F'	884113.8	843427.5	12.479660	7.612814

Table 2: Susceptibility values of some rocks and minerals (Telford *et al*., 1990)

Material	Susceptibility x 10^{-3} (SI)
Air	About 0
Quartz	-0.01
Sphalerite	0.4
Pyrite	0.05 - 5
Hematite	0.5 - 35
Ilmenite	300 - 3500
Clays	0.4
Chromite	3 - 110
Magnetite	1200 - 19200
Calcite	-0.001 - -0.01

Figures 4 to 9 show the modeled bodies of the subsurface structures causing anomalies on all the profiles. The green curve represents the observed magnetic field values while the black curve represents the calculated magnetic field values.
The parameters of each causative body extracted from the models are body center, maximum width, depth to body, depth extent and susceptibility. The susceptibility values were compared with standard susceptibility values of rocks and minerals (Table 2) to give an idea of minerals likely to be present in the study area. Table 3 gives the summary of the body parameters for all the six profiles. The locations of the bodies are given in Table 4.

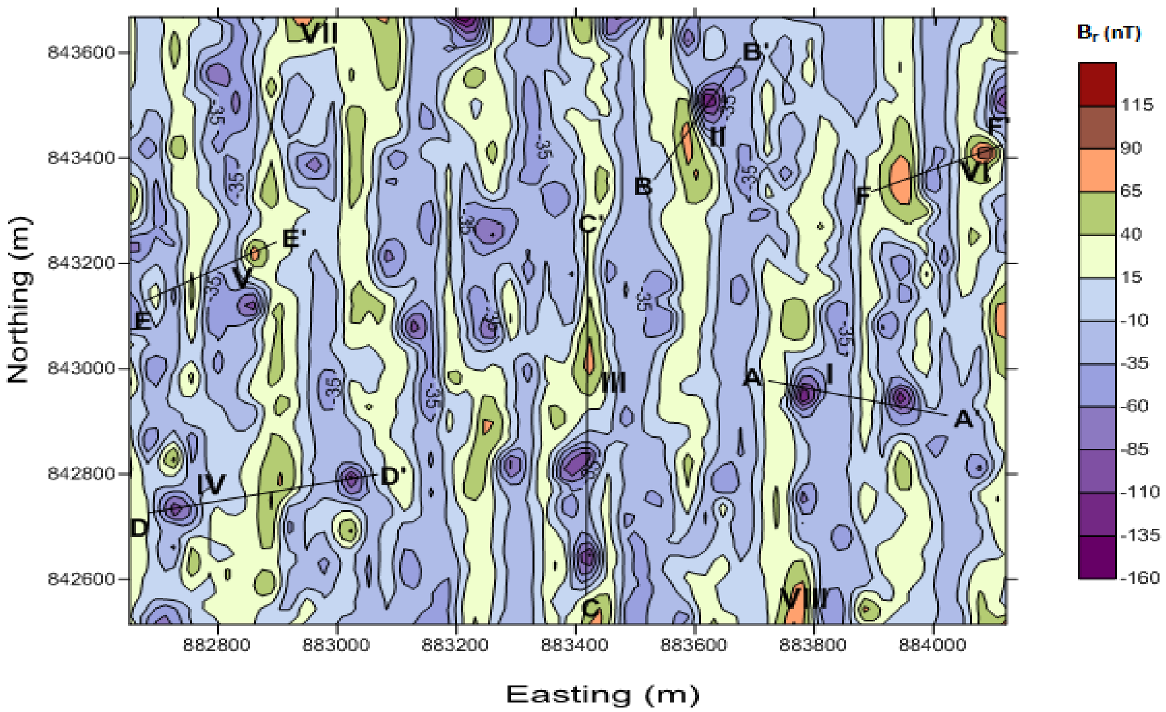

Fig. 3: Residual map showing the profiles

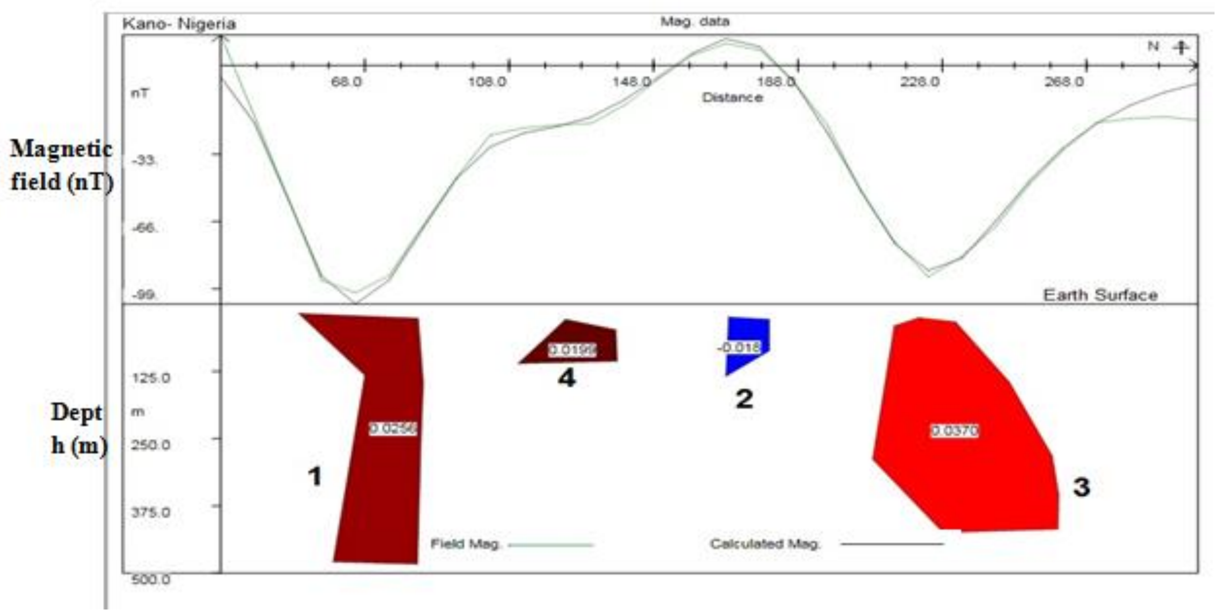

Fig. 4: Modeled bodies of the subsurface structures causing anomalies on profile AA'

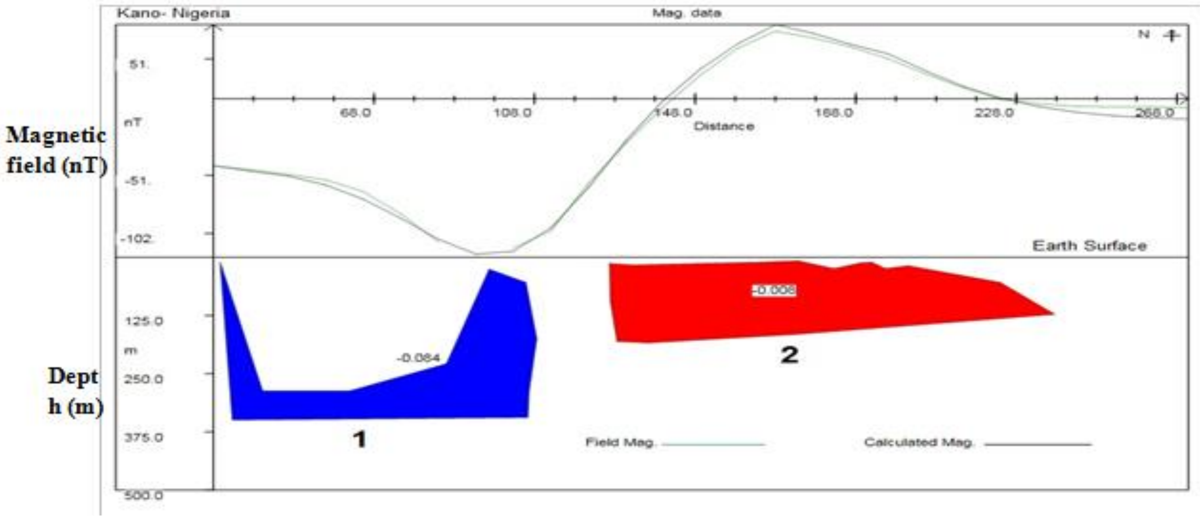

Fig. 5: Modeled bodies of the subsurface structures causing anomalies on profiles BB'

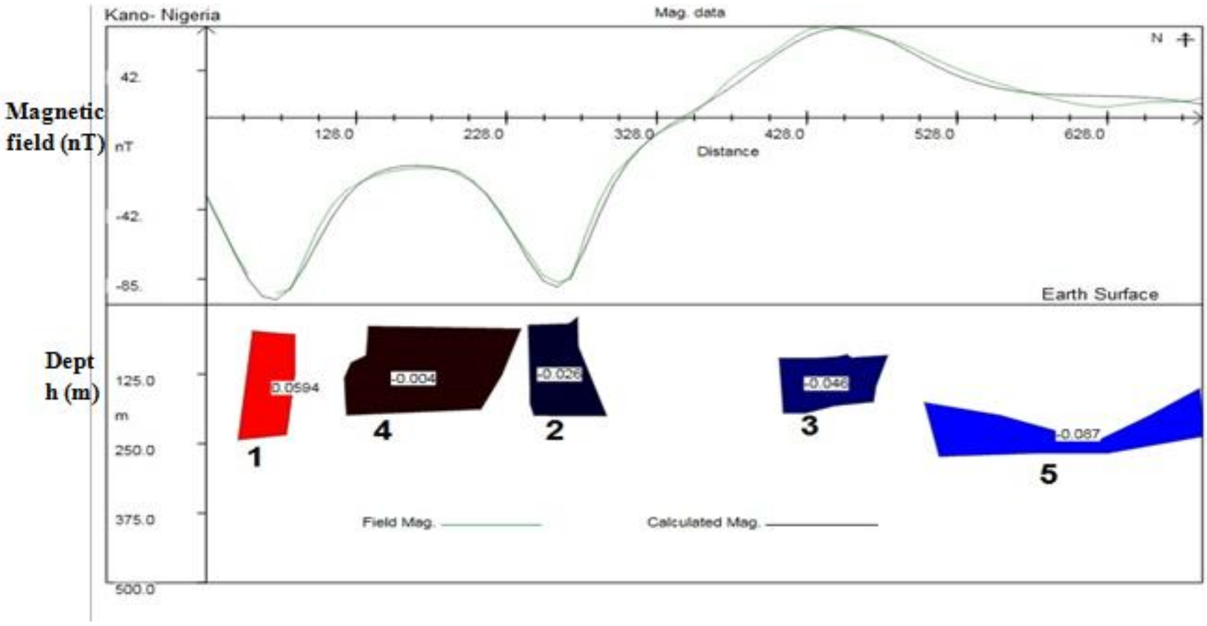

Fig. 6: Modeled bodies of the subsurface structures causing anomalies on profiles CC'

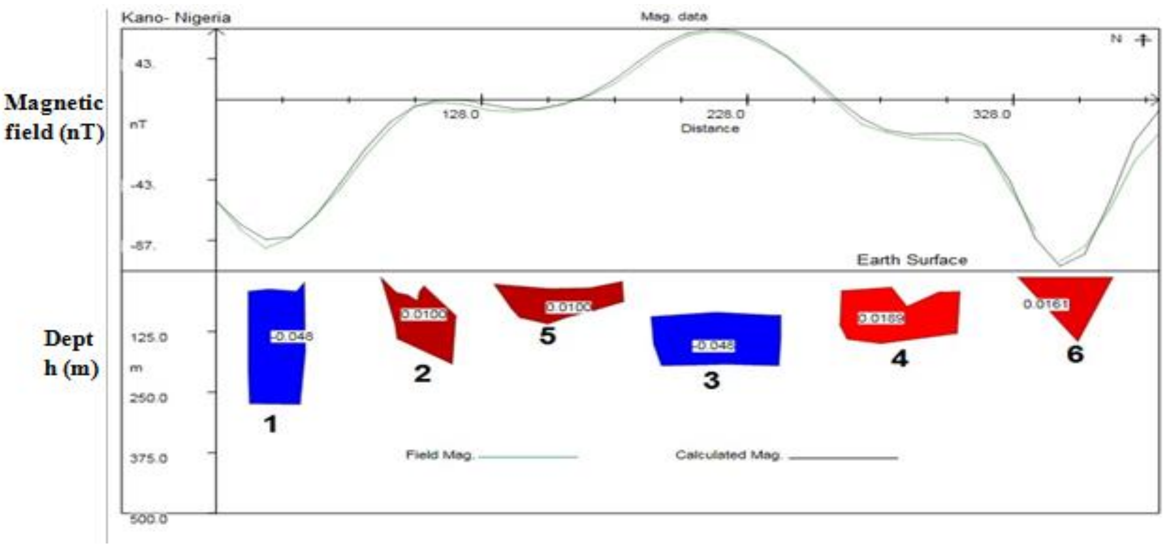

Fig. 7: Modeled bodies of the subsurface structures causing anomalies on profiles DD'

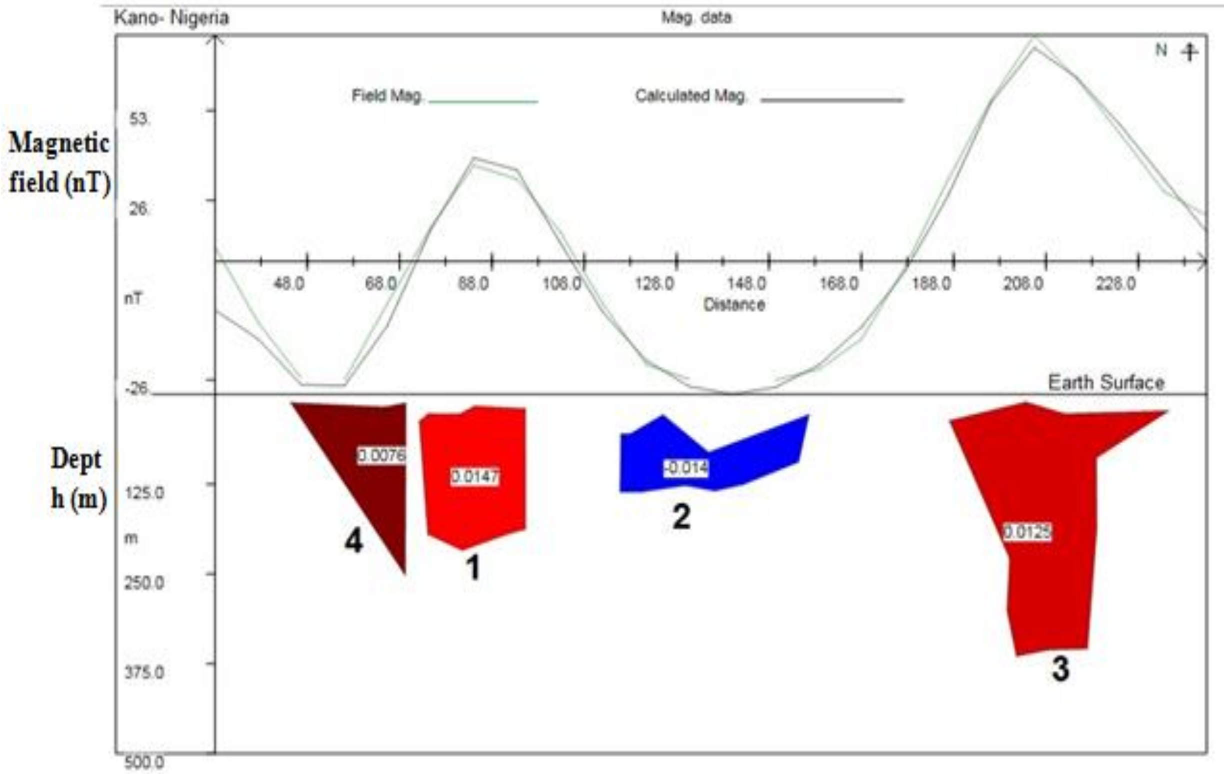

Fig. 8: Modeled bodies of the subsurface structures causing anomalies on profiles EE'

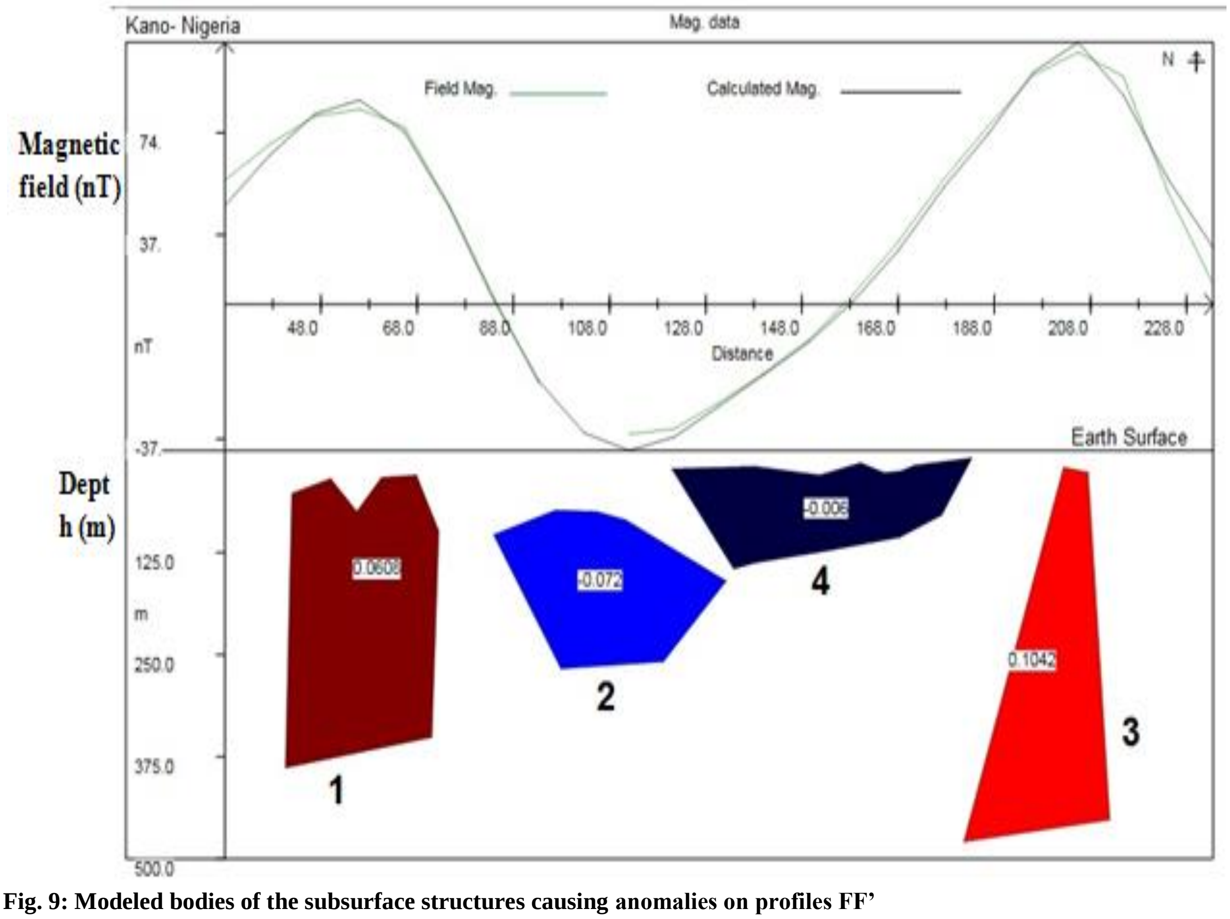

Fig. 9: Modeled bodies of the subsurface structures causing anomalies on profiles FF'

Table 3: Causative body parameters

Model	Body number	Body center (m)	Maximum width (m)	Depth to Body (m)	Depth extent (m)	Susceptibility	Mineral suspected
AA'	1	66.92	34.53	17.43	465.61	0.0257	Hematite/ Chromite
	2	174.09	12.10	23.88	110.45	-0.0188	Quartz
	3	234.55	51.53	25.37	398.81	0.0370	Chromite
	4	124.20	27.48	28.36	82.09	0.0199	Hematite/ Chromite
BB'	1	69.12	78.89	10.45	338.81	-0.0842	Quartz
	2	182.16	110.82	7.46	176.12	-0.0082	Quartz
CC'	1	68.16	37.76	47.41	195.52	0.0594	Chromite
	2	268.58	52.09	22.39	177.61	-0.0266	Quartz
	3	445.59	72.22	89.55	105.45	-0.0465	Quartz
	4	178.83	117.54	38.81	159.70	-0.0050	Quartz
	5	606.57	200.72	150.75	122.10	-0.0879	Quartz
DD'	1	50.94	21.50	23.25	251.86	-0.0489	Quartz
	2	104.17	28.27	12.76	179.10	0.0100	Hematite/ Chromite
	3	216.16	48.85	84.89	110.45	-0.0480	Quartz
	4	285.41	45.15	33.29	116.42	0.0189	Hematite/ Chromite
	5	157.08	48.77	21.37	88.06	0.0100	Hematite/ Chromite
	6	347.68	35.73	12.86	132.69	0.0161	Hematite/ Chromite
EE'	1	83.78	23.05	16.42	200.74	0.0147	Hematite/ Chromite
	2	136.23	40.91	28.36	107.39	-0.0140	Quartz
	3	210.88	4.48	10.73	353.73	0.0125	Hematite/ Chromite
	4	56.88	24.92	11.64	239.57	0.0076	Hematite/ Chromite
FF'	1	56.58	31.85	29.85	358.49	0.0608	Chromite
	2	108.08	48.36	73.13	194.03	-0.0723	Quartz
	3	196.84	30.30	20.71	458.21	0.1043	Chromite
	4	152.17	62.31	8.96	135.82	-0.0065	Quartz

Table 4: Locations of the causative bodies

Profile	Body	Easting (m)	Northing (m)	Latitude in Degrees	Longitude in Degrees
AA'	1	883782.0	842966.6	12.47662	7.608676
	2	883883.3	842948.8	12.47754	7.608508
	3	883944.1	842933.6	12.47809	7.608367
	4	883863.0	842951.4	12.47736	7.608533
BB'	1	883581.9	843447.8	12.47485	7.613036
	2	883622.4	843518.7	12.47522	7.613673
CC'	1	883414.8	842619.6	12.47328	7.605570
	2	883417.3	842784.2	12.47331	7.607056
	3	883417.3	842829.8	12.47331	7.607468
	4	883414.8	842685.4	12.47328	7.606164
	5	883417.3	843032.4	12.47333	7.609297
DD'	1	882700.6	842733.5	12.46682	7.606650
	2	882753.7	842743.7	12.4673	7.606738
	3	882867.7	842769.0	12.46834	7.606958
	4	882956.4	842789.3	12.46914	7.607135
	5	882842.4	842761.4	12.46811	7.606892
	6	883019.7	842794.3	12.46971	7.607176
EE'	1	882693.0	843141.3	12.46678	7.610333
	2	882753.7	843176.8	12.46733	7.610649
	3	882857.6	843224.9	12.46828	7.611076
	4	882677.8	843131.2	12.46664	7.610243
FF'	1	883944.1	843361.6	12.47812	7.612231
	2	883994.7	843381.9	12.47858	7.612411
	3	884083.4	843417.4	12.47938	7.612725
	4	884042.9	843397.1	12.47902	7.612545

The susceptibility values suggest that the study area comprises of iron and chromium rich minerals as well as quartz.

From Table 2, the depth to the modeled bodies ranges from 7.46 to 150.75 m. This agrees fairly well with previous works done in the study area viz, Bagare *et al.* (2018) who got 184 m in their geoelectric study, Shehu *et al.* (2019) who obtained a range of 14.6 to 261.4 m in their depth estimation using Source Parameter Imaging technique and Shehu *et al.* (2021) who obtained 6.5 to 39.8 m for contact model and 8.9 m to 51.3 m for dyke model in their depth estimation using Euler deconvolution technique. This agreement with previous works gives us confidence on other results obtained from this study.

Conclusion

In this study, we were able to estimate the causative body parameter around the Schist belt areas of Kano State using Mag2DC software package. The parameters obtained include body center, depth of the body, depth extent, maximum width and body's susceptibility. The depth to body was compared with previous works and found to agree fairly well; this gave us confidence on other results from the study. The susceptibility values suggest that the study area comprises of iron and chromium rich minerals as well as quartz.

We recommend that geochemical analysis should be carried out on rock samples in the study area to ascertain the actual minerals present.

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