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Ground Magnetic Survey over Lead-Zinc Mineralization in Edor, Cross River State, Nigeria

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Abstract
Ground magnetic survey was carried out to investigation Lead-Zinc ore presence in Edor area of Cross River State, Nigeria. Magnetic-intensity profiles were made along seven profile lines over the target area. All the magnetic lows match in position with aeromagnetic lows which have been associated with Pb-Zn mineralisations in the area. It was therefore concluded that the Pb-Zn mineralisation is depicted by magnetic lows.

Introduction

Magnetic survey is one of the tools used by exploration geophysicists in their search for mineral-bearing ore bodies. Through magnetic Survey, the Earth's magnetic field and the spatial variation in it can be analyzed. The object of the survey was a reconnaissance of the area and magnetic-intensity profiles were made along seven profile lines over the target area. Lead-Zinc ores usually occur together. They are often associated with copper and silver. They occur in commercial quantities in the northeast and central region of Nigeria (Victor, Onwuemesi, Aniwetalu and Emmanuel, 2015).

Geology of the Deposit

The epigenetic Pb-Zn deposits of the southern Benue Valley (Nigeria) are localized within Cretaceous sediments of an intracontinental rift basin. Fluid inclusion studies of vein minerals from the Abakaliki and Ishiagu orebodies show that sphalerite and quartz were deposited at relatively low temperatures (102–175 °C), with ore-fluid salinity mostly in the range of 17–25 equiv. wt% NaCl. Trace-element contents of sphalerite and galena are also consistent with the low temperature of formation and epigenetic origin. On the basis of the geotectonic setting, the mode of occurrence and fluid-inclusion characteristics, mineralization is attributed to connate brines set into motion by a high geothermal gradient accompanying continental rifting. Mineral deposition was caused principally by rapid cooling due to either reaction with wall rocks or mixing with meteoric or descending water of low salinity.

Review of previous work

Many workers have carried out some studies of the lead-zinc mineralization of the cretaceous sediments of southern Nigeria (Olade and Morton, 1985; Ofoegbu, 1985; Fatoye, Ibitomi and Omada 2014, Victor *et al.*, 2015, Ogundipe and Obasi, 2016). According to Victor *et al.*, (2015), The Pb-Zn deposits in Ishiagu area appear to be the southern limit of mineralization in the Benue Trough and the Pb-Zn mineralized zone extends over a distance of 500 km in a narrow belt from Ishiagu in the lower Benue Trough to Zurak in the upper Benue Trough, likewise the extent of igneous intrusions in the Benue Trough. Nwachukwu (1972) and Wright (1976) have shown that the Asu River group of sediments deposited during the Transgressive phase of the middle Albian have undergone a minor folding during the Cenomanian time. These sediments were later refolded during the Santonian tectonic episode associated with igneous activities (Short and Stauble, 1967, Nwachukwu, 1972). Associated with these igneous activities are the lead-zinc mineralization in the area (Orajaka, 1975) and the mineralization coincides with the main belt of igneous rocks.

Okezie (1957) mapped the igneous and structural geology of Ezekwe, Wanikanda, Oju and Nkpume-Akwaokutu districts of Ogoja, Benue and Abakaliki provinces and was able to locate igneous intrusions of different structural compositions ranging from gabbro, Augite-diorite, Micro-diorite and lead-zinc mineralization have been established on some of the Augite-diorite intrusions. Ezepue (1992) noted that Pb-Zn deposits of Ishiagu are associated with the shales of the Asu-River Group and that they occur along the NW-SE trending fractures. He found the deposits to occur on the Abakaliki anticlinorium and remarked that there was a close correlation between the Pb-Zn mineralization and the structures.

Farrington (1952) showed the Pb-Zn mineralization to be commonly associated with dolerite and albitized dolerites in the anticlinal structures and suggested a hydrothermal origin for the mineralization. Grant (1971) is rather of the opinion that a more likely source is deep circulating hot brines which leached metals from the sediments and underlying crystalline basement. The igneous bodies acted both as source of heat for the circulating fluid and sites for emplacement of the mineral veins. Wright (1981) attributed their altered condition to the passage hydrothermal solution through them and to some extent, metasomatism resulting from intrusion into the wet sediments.

Survey Method

Seven magnetic traverses were run. Measurements were taken at 90m. The base station was reoccupied after every three hours to determine the diurnal effects and to ascertain the drift of the instrument if any. The maximum difference recorded at the base station was 1gammas in nine hours and the average change per reoccupation of the base station was about 2 gammas. The insignificance of this change made the corrections for the above factors unnecessary. Moreover in mineral prospecting and all other cases where the anomaly of interest is as large as 500gammas such corrections are not required (Telford *et al* 1976). This survey was carried out on a local scale and in addition the site is a fairly flat area whose maximum elevation difference is 11m. It is known that in sedimentary formation magnetic susceptibility variations are not very erratic and as such terrain corrections were not necessary. A total of 359 interval vertical magnetic intensity readings were taken from the seven lines and these were summoned up from which an average of 1445 gammas was obtained. This average was regarded as the regional value which was subsequently subtracted from each of the station reading to obtain the residual magnetic anomaly.

Results and Discussions

The instrument readings as well as the residual values in line 1 are shown on Table 1. This is typical of other lines. The residual values (vertical magnetic intensity) were plotted against the station distance (Figure 1-4). The plots of line 1 exhibit changes in vertical magnetic intensity values and in anomaly polarity throughout the entire 4km length. These changes in intensity and polarity reflect surface magnetic inhomogeneity. The residual value of line 2 a magnetic low centered at 720m. The magnet low has a lateral extent of 2.3km and a peak value of -600gammas.

Table 1: Magnetic Readings Line 1

OB.PT. (m)	INST.Readings	SENS	Value IN	Polarity	Time	Residual
0	200	3	2016	+	8.50	571
90	240	2	2419	+	9.50	974
180	240	3	2419	+	10.07	974
470	120	3	1210	+	10.30	-236
360	180	2	1814	+	10.35	369
450	80	4	806	+	10.45	-639
540	120	3	1210	+	10.51	-236
630	520	2	5242	+	11.01	3797
720	60	3	605	+	11.11	-840
810	80	4	806	+	11.20	-639
900	70	4	706	+	11.30	-739
990	200	3	2016	+	11.40	571
1080	500	2	5040	+	11.50	3595
1170	80	3	806	-	12.02	-639
1260	80	3	806	-	12.10	-639
1350	40	4	403	+	12.17	-1042
1440	330	1	3326	+	12.27	1881
1530	110	2	1109	-	12.35	-336
1620	200	2	2016	-	12.45	571
1710	320	2	3226	-	12.55	1781
0	220	3	2218	+	1.30	773
1800	200	2	2016	+	2.00	571
1890	180	2	1814	+	2.10	369
1980	200	2	2016	+	2.20	571
2070	200	2	2218	+	2.32	571
2160	220	2	1008	+	2.40	773
2250	100	3	1008	+	2.50	-437
2340	120	3	1210	-	2.50	-236
2430	240	3	2419	-	3.06	974
2520	185	3	1865	-	3.16	420
2610	640	2	6451	+	3.20	5006
2700	500	2	5040	+	3.30	3595
2790	240	2	2419	+	3.41	974
2880	300	2	3024	+	3.50	1579
2970	320	2	3226	+	4.00	1781
3060	120	3	1210	+	4.08	-236
3150	360	2	3629	+	4.20	2184
3240	80	4	806	+	4.30	-639
3330	240	2	2419	+	4.40	974
3420	240	2	2419	+	4.49	974
3510	190	3	1915	+	5.00	470
3600	200	3	2016	+	5.07	571
3690	200	3	2016	+	5.10	571
3780	220	3	2218	+	5.15	773
3870	180	3	1814	+	5.20	369

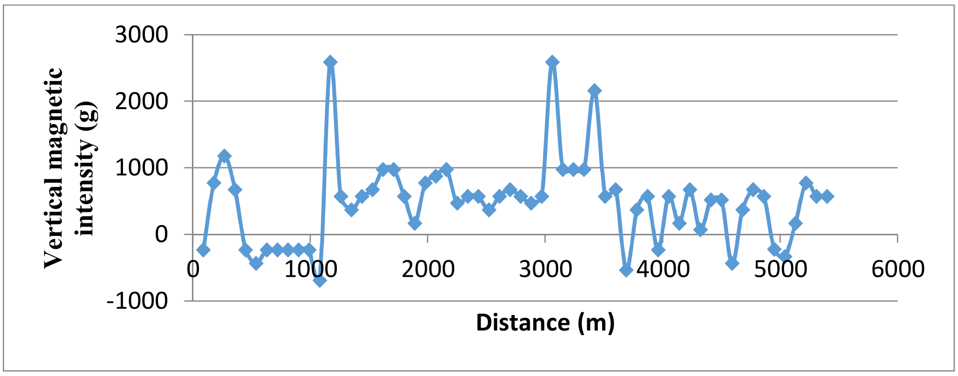

Figure 1: Line 1 Profile

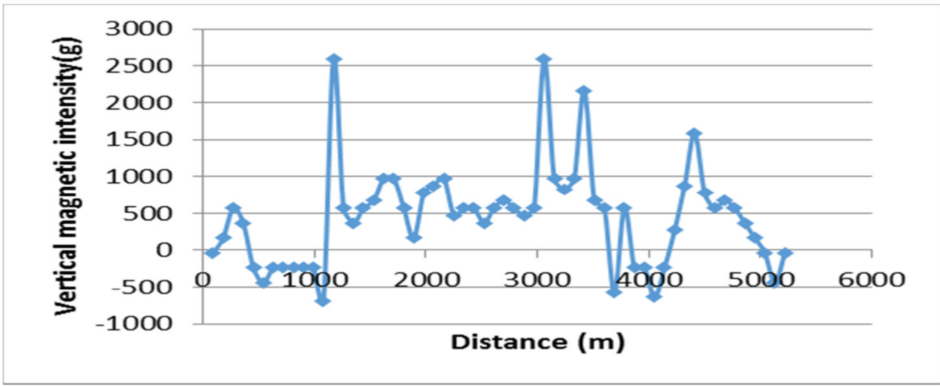

Figure 2: Line 2 Profile

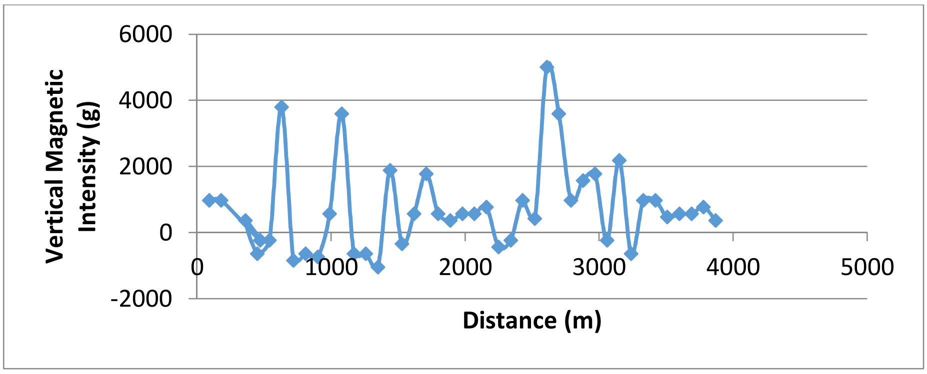

Figure 3: Line 3 Profile

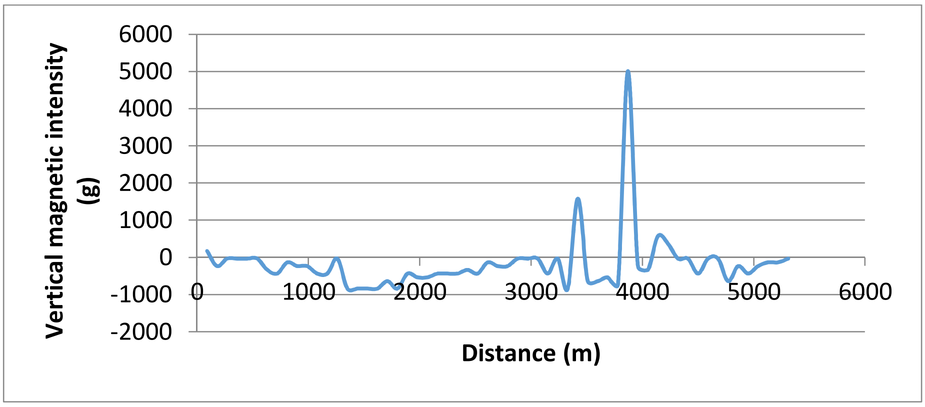

Figure 4: Line 4 Profile

Five kilometers of line 3 was covered by magnetic. The graph of the residual vertical magnetic intensity values plotted against the stations. Line 3 does not show any significant anomaly anywhere along the line. Rather the graph goes from positive to negative over very short distance in response to near surface magnetic in homogeneities. This picture agrees with the EM survey profile over the same area according to Mama and Eze (1985) which also only reflects near surface inhomogeneity in conductivity and showed no anomaly that could be associated with an ore body.

Sixty one vertical intensity magnetic readings were taken along line 4 over the distance of 5km. The plot of residual values against the stations shows a negative anomaly which lies between 630m and 2790m along the line from the origin of the profile. The anomaly reaches its negative peak at a distance of 1.5km with a value of about -850grammas.

All the magnetic lows match in position (with little displacement in some cases) with aeromagnetic lows which have been associated with Pb-Zn mineralisations in the area. It could be therefore concluded that the Pb-Zn mineralisation is depicted by EM and magnetic laws. The position of Mhxx corresponds to the point where Okezie (1957) mapped a diorite intrusion as an igneous rock likely to be associated with mineralisation. This result was in contrary to the suggestion of mineralization of the diorite.

Conclusions and Recommendation

A rigourous interpretation of magnetic data over a lead sulphide field serves as an effective tool for delineating probable mineralization areas. This survey was able to identify the NE-SW trending fractures. Magnetic survey must, however, only be used as a complementary exploration tool for lead sulphide.

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