SP Anomalies Around Abakaliki Anticlinorium of Southeastern Nigeria.

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ABSTRACT

The self-potential method was employed to investigate the zones of mineralization within the Abakaliki High. The survey was done at the left flank of the Enugu-Abakaliki expressway using the one fixed-one movable electrode technique on a grid measuring 2.6km by 2.0km. Seventy-five observations were made within the grid. It was discovered that more than 70% of the study area recorded high negative SP values (-500mv - 800mv) indicating a zone of mineralization while some other parts showed zones of little or no mineralization due to their low SP values. The iso-potential map obtained shows a number of elongated centers with maxima between -0.5v and -0.9v.

According to Beck (1981) pyrite and pyrrhotite are the main ore bodies that consistently produce high SP values owing to their high iron content. This covers an extent between 600 and 1000m. The observed potentials are direct result of the oxidation process of the pyrite/pyrrhotite ore body below the crustal mass. This is confirmed by drilling. Thus, the study area was a typical zone of mineralization with pyrite as the probable causative ore body.

(Keywords: self-potential, pyrrhotite, mineralization, ore body, pyrite)

INTRODUCTION

This work was carried out to investigate the trend and length of lead-zinc mineralization in Abakaliki town by the use of self-potential for spontaneous potential techniques. The Abakaliki (anticlinorium) shale is within the Anambra sedimentary basin, which was primarily formed by the rift faulting of the Nigeria Precambrian rocks to the Benue Trough (Ajayi and Ajakaiye, 1981; Murat, 1972). It was formed within the first depositional phase of the sediment within the trough and is in filled with thick accumulations of predominantly Cretaceous rocks thinner sequence of Cenozoic rocks. Geological, the Abakaliki High is actually an aborted rift, system (i.e., a rift system that was to be, but failed to be) (Murat, 1972; Petters and Ekweozor, 1982; Uko et al., 1992).

At depositional actions, progressed minerals began to form resulting into ore body formation within the rock. The mineralization processes set in due to the contemporaneous, geothermal, and tectonostratigraphic processes during the depositional process (Murat, 1972). It is believed that this rock contains a lot of various minerals, which exist as ores or trace elements (e.g. lead, zinc, quartz, sphalerite, galena, and chalcopyrite) (Offodile, 1975).

At a particular area, a predominant of the feeder rock ore body around Abakaliki area, was investigated in this study. The study area is located a few kilometers SE of Abakaliki town before the Iyiokwu River bridge along the Enugu-Ogoja new highway. This area, as shown in the map (Figure 1), is within the geographical location of 8^o 04'- 8^o13'E and 5^o 58' – 6^o 03'N (GSN, 1955).

SPECIFIC OBJECTIVES

One of the aims of this study is to investigate if the process of mineralization has taken place in the study area. It is believed, like the Cretaceous Benue valley, that Abakaliki is economically important with the occurrence of valuable minerals in its subsurface. Again, according to Offodile (1975), the interest this belief generated has instigated the urge to predict or suggest the particular ore body formed if at all there has been mineralization process. Naturally, the significance and relevance of minerals to man cannot be over-looked. So, another aim is to investigate the predominant mineral formed in the study area.

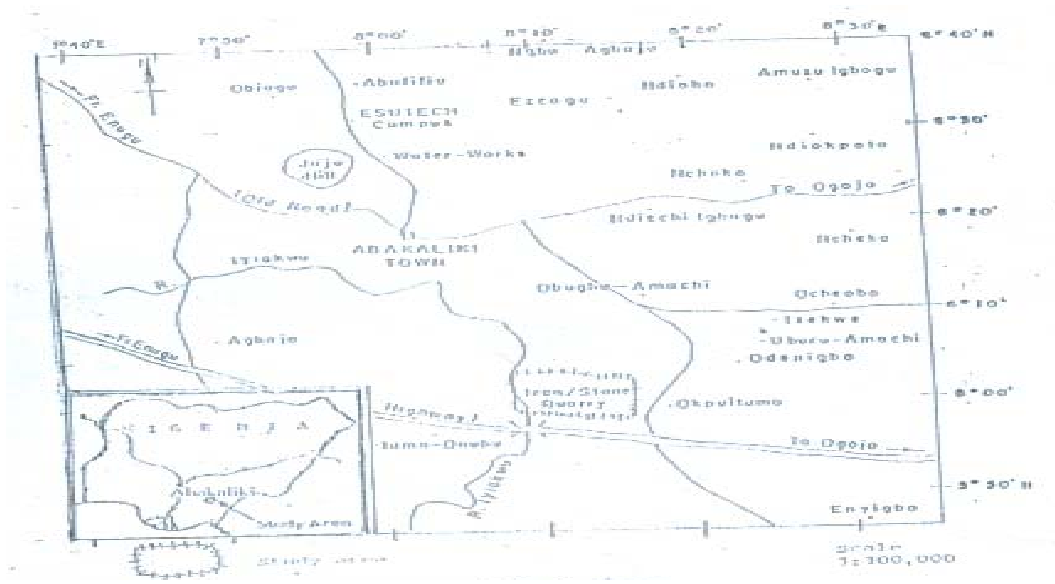

Figure 1: Location Map of Study Area.

METHODOLOGY/FIELD TECHNIQUE

The geophysical technique employed in this study is the SP method. Specifically one electrode was fixed while the other was moved on the 2.6 km by 2.0 km grid. The direct potential method (Beck, 1981) was used. This measurement grid is shown in Figure 2.

The near-uniform grid was divided into five stations and the SP value was measured at each point of twenty (20) meter-intervals with the signs noted. The technique involves the insertion of two non-polarizable electrodes perpendicularly driven into the ground (twenty meters apart) using a high impedance voltmeter.

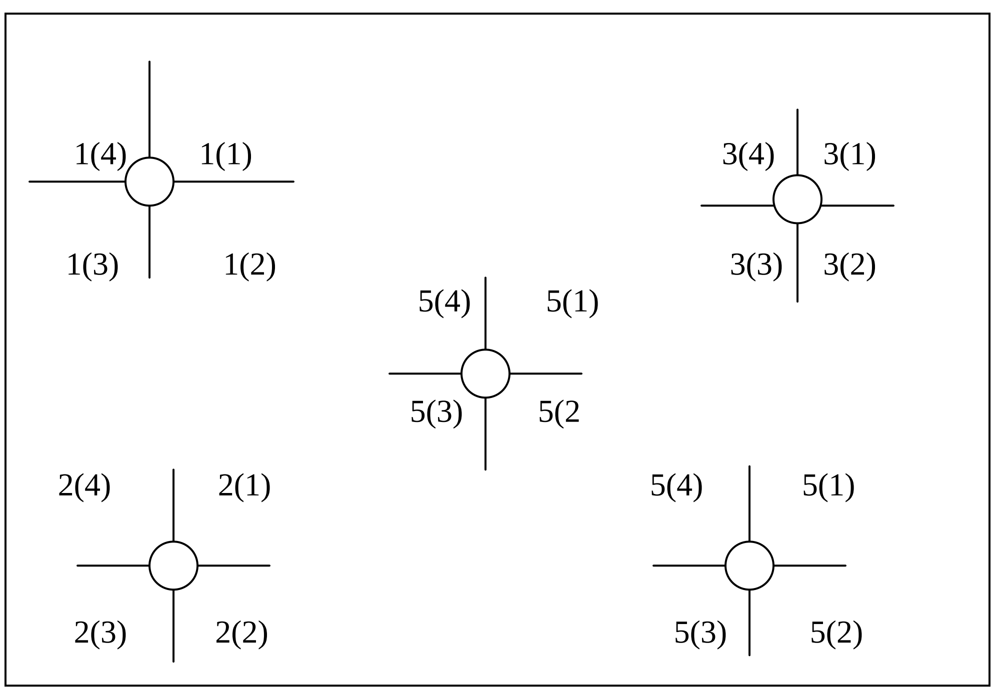

Figure 2: Measurement Grid (not to scale).

The separation between fixed electrode and non-fixed (movable) electrode was 20m. Prior to taking measurements, wooden pegs were pegged along a traverse by 20m intervals i.e. distance (x) between the electrode were 20, 40, 60, 80,……, 300m at each of the five different stations, four sets of fifteen readings were recorded. The instrumentation assemblage comprised of two non-polarizable electrodes, two reels of long insulated cables and a very high input impedance DC voltmeter of range -5000 mV to +5000 mV.

DATA ACQUISITION

With the instrument arrangement described above, the resulting data at each of the measurement points established along the five profiles contained in the grid for taking data are shown below as in Table 1. These data in the table were obtained by systematic procedure which was explained earlier.

DATA ANALYSES AND INTERPRETATION

The data shown in the table were contoured at 100 mV interval as shown in Figure 3. Three profiles (sections) AA', BB' and CC' were taken across the iso-potential contour map. Points A and C are in the south-western part of the study area while point B is in the southeastern part as shown. The centers of the major negative closures (-600 mV and – 700 mV) as shown in Figure 3a located along profile AA' are about 880 m apart. These anomalies also generally trend in a N60^{o}E direction approximately with the southwestern having a larger lateral extent (about 400m) than the north-central anomaly which is roughly 200m.

Two smaller anomalies of equal amplitude (-500 mV) are located at the northwestern and northeastern portions of the study area (Chukwu, 1997) and they are located along profiles BB' and CC', respectively. It is possible, from the profiles to obtain some information about the size of the ore body, there is little or no need obtaining information about the depth since only shallow bodies are likely to exhibit spontaneous polarization potentials (Beck, 1981; Chukwu, 2003 and Dobrin, 1983).

High self-potential anomalies are found in the vicinity of bodies, which are often readily oxidized. For consistently producing strong negative SP anomalies, pyrite\pyrrhotite is evidently present because pyrite/pyrrhotite exhibit characteristic high negative SP anomalies (Chukwu, 1997; Nwachukwu, 2001). Thus, this is the primary sulphide mass underlying the study area because from field investigation the self-potential drop of between 0.6 and 0.8 volt strongly indicate the presence of the ore body due to their high iron contents (Sato and Mooney, 1960; Leney, 1966; Abimbola et al, 1999). This is confirmed by the result of drilling, blasting and crushing of ironstone in the vicinity by the then Anambra State Ministry of Works and Solid Minerals (Ozoemena, 1995 and Nwachukwu, 2001).

RESULTS AND CONCLUSION

Field evidence suggests the existence of weathering in the rock within the study area. The area contains huge amount of ferrogenized sandstone even in commercial quantity. The sandstone assumes this nature due to tropical conditions.

The ferrous ions (Fe^{2+}) change to ferric ions (Fe^{3+}) which give rise to the reddish coloration observed in the rock samples. The large negative SP anomalies indicate mineralization process in the mapped area and this is suggestive of the fact that ore bodies exist therein.

The sets of reading obtained in Table 1 show that the SP anomaly within the area is not evenly distributed. Pyrite (F_eS_2) contains more iron content than pyrrhotite (F_eS) and they are the two sulphide ore bodies that produce the most consistent and strong values. The SP values normally associated with pyrrhotite and pyrite are 600 mV and 800 mV, respectively (Sato and Mooney, 1960).

Since the spontaneous potential anomalies are not uniform within the surveyed area, this implies, according to Lindgren (1933), Beck (1981) and Nwenifumbo (1993) that the rate of mineralization within parts of the surveyed area varies depending on some certain factors like type of metal, ore body in existence, fissuring, permeability, topography, etc. Data at the measured points were negative for, most of the observations made; about 93% of the data obtained were negative. This reveals the mineralogical trend more vividly.

Table 1: SP Field Data.

Distance	Profile 1 pot. drop . 10^2 mV				Profile 2 pot. drop . 10^2 mV				Profile 3 pot. drop . 10^2 mV				Profile 4 pot. drop . 10^2 mV				Profile 5 pot. drop. 10^2 mV			
$X_{(m)}$	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4
20	12	2	3	1	2	1	1	3	6	11	4	12	2	2	2	2	1	2	2	2
40	19	12	6	6	4	3	6	2	5	8	28	9	2	2	2	2	0	3	3	3
60	10	11	8	9	3	5	4	2	7	6	30	8	3	2	3	3	1	3	3	3
80	7	10	2	5	5	2	6	3	6	4	20	6	3	2	3	4	2	3	3	3
100	12	20	10	6	5	5	9	2	4	5	18	5	3	1	4	4	2	4	3	2
120	13	19	10	3	3	1	8	4	42	8	22	8	3	2	2	5	2	3	2	3
140	17	11	10	2	2	1	6	5	50	36	8	9	3	2	1	5	3	2	0	2
160	6	12	12	2	4	2	7	5	43	24	21	6	2	3	2	6	3	1	1	2
180	6	7	11	1	2	1	5	4	40	20	16	6	2	2	3	6	2	2	1	3
200	-10	5	12	-1	5	0	4	3	40	0	8	6	2	2	0	7	2	1	0	3
220	-12	6	10	-1	3	1	6	3	31	14	8	4	2	3	4	7	2	2	1	3
240	-13	4	11	-1	5	1	9	-2	30	16	7	4	2	3	3	7	3	2	2	3
260	-11	1	10	-1	4	1	8	-1	-23	21	4	1	1	3	3	7	2	3	3	3
280	-12	4	10	-1	4	1	6	-1	-23	21	3	-	1	3	3	7	3	2	2	3
300	-12	4	10	-1	4	1	6	-2	-23	20	2	-	2	3	3	7	-	2	3	3

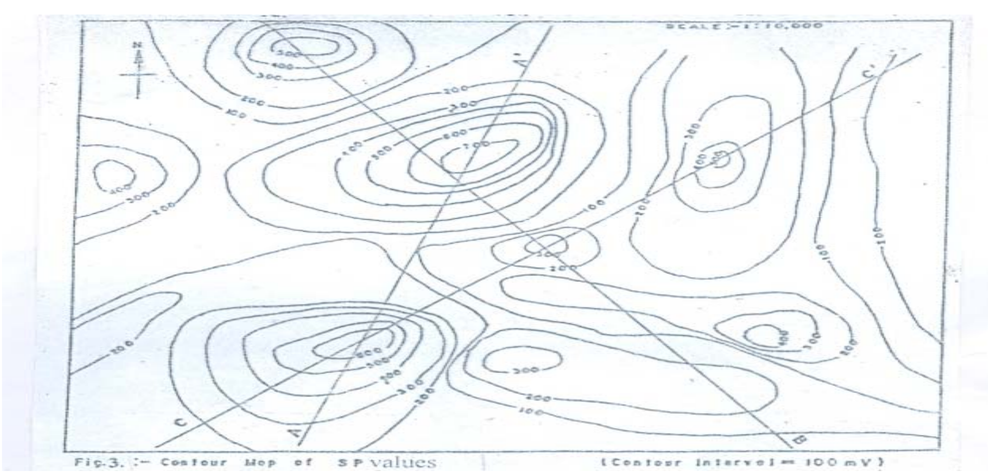

Figure 3: Contour Map of SP Values.

Naturally, commercial ore or mineral does not ordinary occupy the whole volume of a deposit; the ore in most cases is surrounded by mineral of poor grades sometimes fading into the country rock (Beck, 1981). Thus, the non-even distribution of the anomalies suggests that there are possible ore-shoots (parts of a deposit in which the valuable minerals are highly concentrated) within the surveyed area. These ore-shoots, undoubtedly, represent those points where high negative SP values were recorded. Therefore, there has been mineralization process going on in the area of study which gives rise to formation of minerals therein. However, it is verified that this process is not the same all over the shale and this explains why we have non-uniform distribution of SP anomalies. Nwachukwu (2001) and Nwata (1983) asserted that the shale hosted fracture-controlled Abakaliki district ore deposit has been tentatively assigned to the telethermal-leptothermal group on the basis of their mineral association and structures. Hence, both extrusive and intrusive igneous rocks are found in the fold belt in the form of sills and dikes where high temperature and high fluid flow rate within the fractures and fissures result to sulphide ore mineralization system.

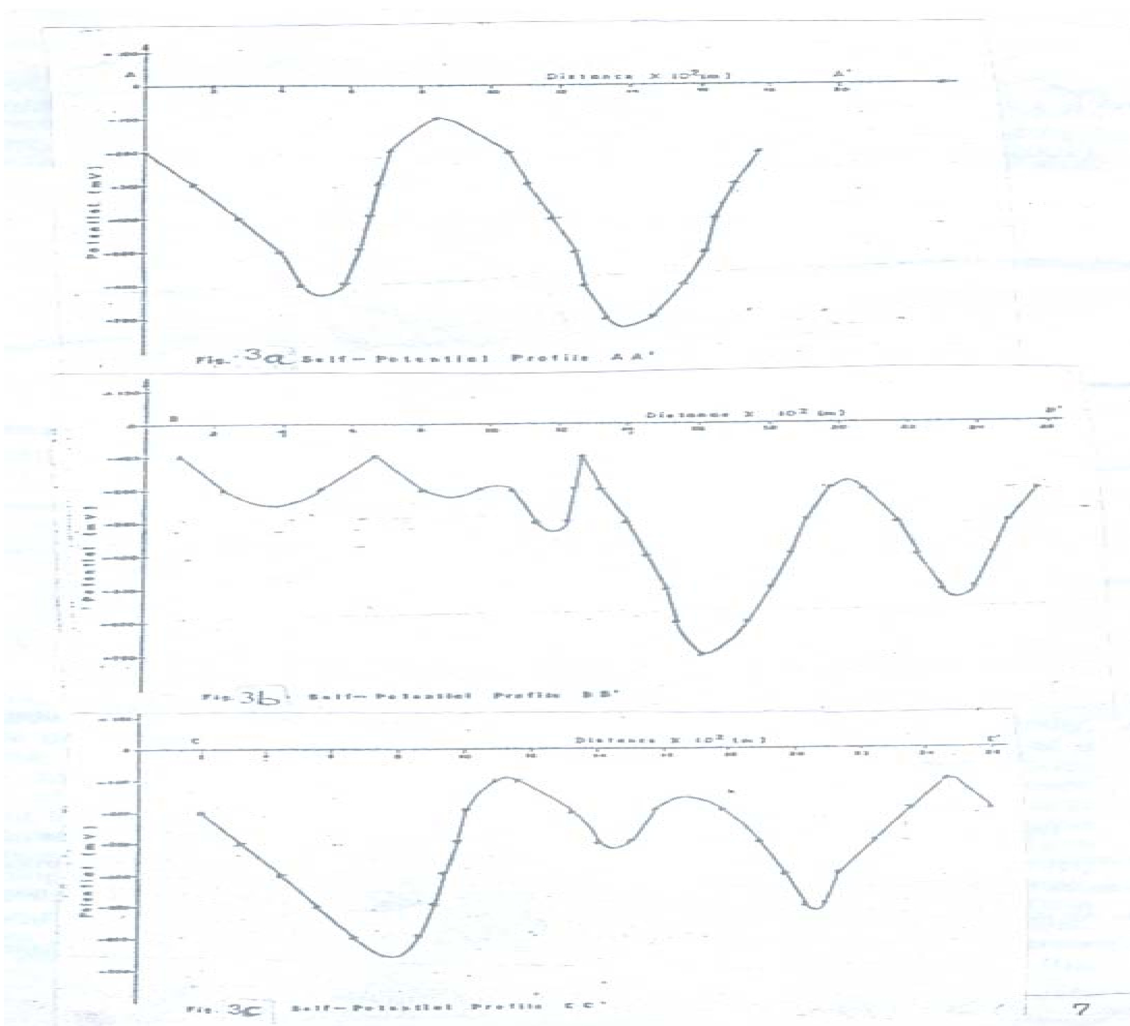

Figure 3: Three Profiles (sections) AA', BB' and CC' Taken Across the Iso-Potential Contour Map.

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