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Electromagnetic Geophysical Prospecting For Groundwater in Basement Complex Terrain: A Case Study of Ola-Oluwa Area of Osun State, Southwestern Nigeria.

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Abstract: *Electromagnetic (EM) survey involving horizontal profiling using ABEM WADI VLF equipment has been employed in prospecting for groundwater occurrence in the Basement complex terrain of Ola-Oluwa local government area of Osun state, southwestern, Nigeria. The qualitative interpretation of the EM data obtained from the survey shows that the amplitude of the filtered and actual real EM anomalies in the study area varies from-79.1% to +0.8% and -2.4% to -37.9% respectively in Ajagba Locality, -26.9% to 47.1% and -42.6% t0 -55.4% respectively in Asa locality, -27.9% to -37.0% and -23.3% to 39.0% respectively in Ikonifin locality, -2.1% to 69.8% and -21.5% to -64.5% in Ikire-Ile respectively, In Baramolu locality, the EM readings in most of the recording stations could not be recorded due to high noise level (possibly from the over head power cables) overriding the EM signals. The EM anomalies in the few stations recorded in this locality vary from -0.2% to 44% and -0.3 to 48% respectively. The EM anomalies in all the localities in the study area are generally negative and devoid of any significant peak positive filtered real anomaly typical of subsurface structure. The typically negative EM amplitude anomalies observed in the study area are diagnostic of conductive overburden. The aquifer potential in the study area is generally poor as accumulation of groundwater will be restricted to the overburden layer since the underlying basement layer is generally devoid of subsurface structure.*
Keywords*: Electromagnetic, Groundwater, Basement complex, Overburden, Anomaly.*

I. Introduction

The supply of potable water in Nigeria is almost entirely restricted to the urban centers and other major towns. The rural areas rarely benefit from such supply. It not surprising therefore that the rural areas are often ravaged by water borne diseases such as typhoid, cholera and guinea worm. In an attempt to make potable water available to the rural communities in Nigeria, effort needs to be made in developing groundwater through the drilling of boreholes. Drilling of productive water borehole depends to a large extent on the pre-drilling geophysical survey employed in locating the suitable site of the borehole.

Electromagnetic (EM) profiling is a widely used geophysical method in the delineation of basement regolith and location of fissured media and associated zones of deep weathering in crystalline terrains (Beeson et al, 1988, Hazell et al, 1988 and Olayinka 2004). Electromagnetic method also constitutes the most reliable means, outside direct mechanical drilling, through which basement structures such as ancient river channels, basement depressions and fractured zones that are of hydrogeological significance can be mapped (Eaton and Watkins, 1970; Vanderberghe, 1982). EM response in basement complex area as observed by Olorunfemi et al, 1995, is strongly influenced by the conductive weathered zone. A very conductive weathered layer will give high amplitude EM response with usually negative polarity.

This study utilizes Electromagnetic geophysical technique in prospecting for suitable location for drilling of borehole in basement complex area of Ola-Oluwa, southwestern Nigeria.

II. Geology And Hydrogeology

The study area is underlain by Precambrian basement complex rocks. Although the basement rocks are concealed beneath variably thick overburden within the survey area, the generalized geological map of Nigeria shows that the area is underlain by migmatite gneiss and fine to medium biotite and biotite muscovite granite (Fig.1). The groundwater occurs in the weathered rocks (regolith or saprolite) and tectonic stress precipitated fractured/fissured, sheared or jointed basement rock. The permeability and storativity of the groundwater system are dependent on secondary structural features such as the extent and volume of fractures, fissures and joints together with the thickness (Clark, 1985). Fracture frequency increases with depth and reaches a maximum at between 25 and 35m but decreases with further increase in depth (Olorunfemi and Fasuyi, 1993). The accumulative fracture frequency is maximum in granite and minimum in schist.

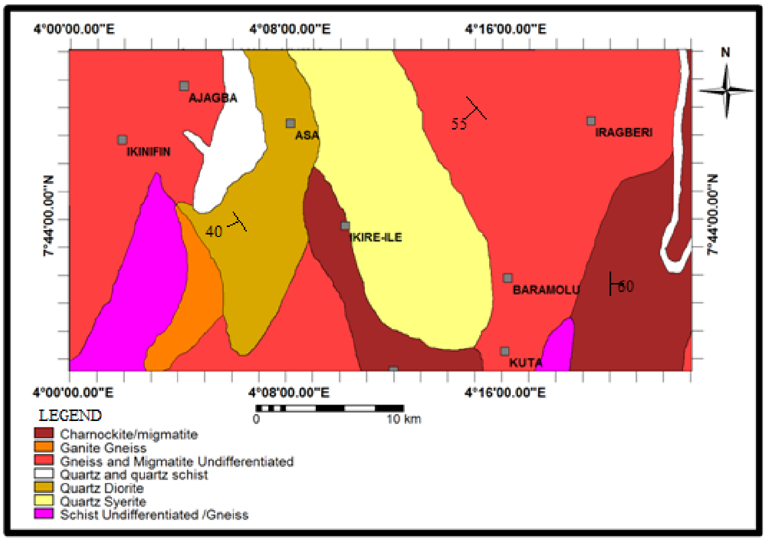

Fig.1 Geological map of the study area

III. Methodology

The EM survey was carried out using the ABEM WADI VLF equipment and the horizontal profiling technique was employed. Measurement of the EM reading was done at station intervals varying from 10 – 50m depending on the length of the traverse. The field data are presented as EM profiles.

The interpretation of the EM profile involves identification of signatures or patterns that are diagnostic of fractures or thick overburden. Such targets as displayed in Fig 2 below are characterized by peak positive amplitude filtered real and S – shaped anomaly whose inflexion point lies directly above the vertically dipping fractured zone and a high amplitude EM response with a negative polarity. A combination of the above EM characteristics is a strong indication of the presence of a conductive near vertical fractured zone or lithological contact or interface and a conductive overburden respectively (Olorunfemi et al, 1995).

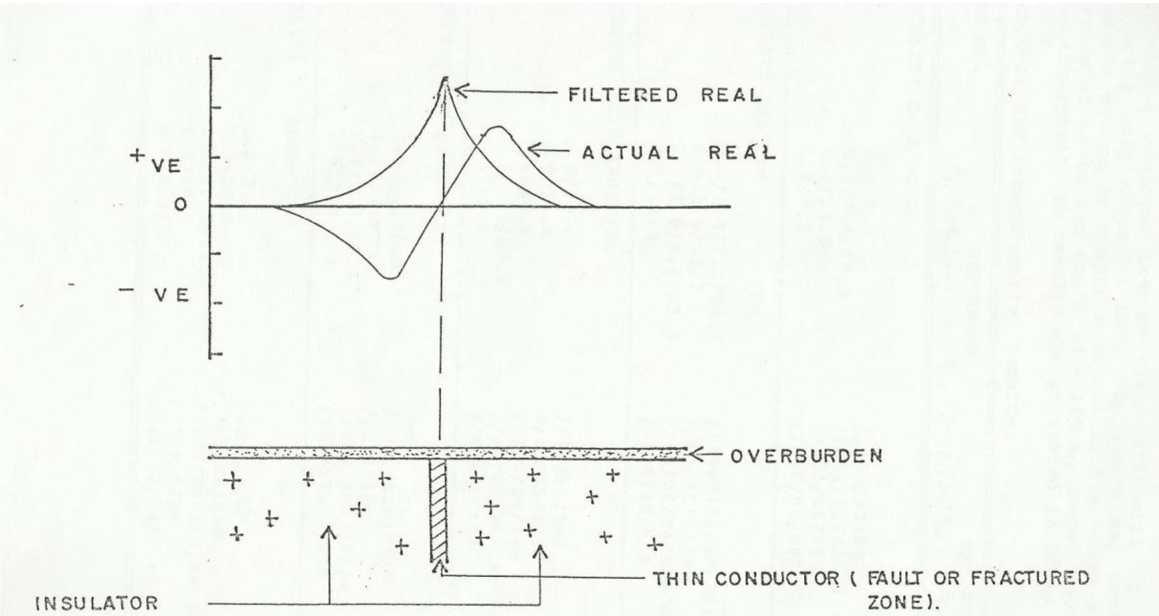

Fig. 2 Theoretical EM (VLF) response over a vertical dipping conductive sheet (fault, fractured, fissured zone or lithological contact)

IV. Results

The results of VLF profiles conducted at AJagba, Asa, Ikonifin, Ikire-Ile and Baramolu are presented in Table 1 below.

Table 1: EM amplitude signals (actual and filtered real) obtained from the study area.

AJAGBA			ASA			IKONIFIN			IKIRE-ILE			BARAMOLU		
Station No.	Filtered real (%)	Actual real(%)	Station No.	Filterd real(%)	Actual real(%)	Station No.	Filtered real(%)	Actual real(%)	Station No.	Filtered Real(%)	Actual Real(%)	Station No.	Filtered Real(%)	Actual Real(%)
0	-35.4	-24.6	0	-26.9	-43.7	0	0	-34.1	0	-69.8	-58.4	0	-0.2	-0.3
1	-19.8	-26.5	1	-42.2	-47.0	2	-30.7	-38.5	1	-59.8	-51.8	1	-30	-36
2	-79.1	-74.5	2	-47.1	-55.4	3	-27.9	-23.3	1.5	-45.5	-60.2	2	-44	-48
3	-72.3	-21.9	3	-56.5	-42.6	4	-37.0	-33.8	2	-66.2	-52.8	3	-42	-46
4	-37.7	-32.4	4	-45.3	HNL	5	-29.5	-35.6	3	-50.4	-64.5			
5	-38.1	-37.9	5	-41.0	HNL	6	-35.6	-27.6	4	-55	-43.7			
6	-32.3	-31.7	5.5	-40.2	HNL	6.5	-29.6	-27.9	4.5	-53.6	-35.4			
7	-34.5	-35.2	6	-36.1	HNL	7	-28.0	-39.0	5	-43	-26.7			
8	-33.5	HNL	7	-39.0	HNL	8	-35.9	-33.2	6	-39	-48			
9	-30.4	-20.2	7.5	-41.3	HNL	9	0.0	-35.0	7	-46.2	-54.2			
9.5	+0.8	-2.4	8	HNL	HNL				8	-45.8	-21.5			
10	-3.8	HNL	9	HNL	HNL				9	-49.4	-58			
11	HNL	HNL	10	HNL	HNL				10	-43.3	-31.9			
12	HNL	HNL	10.5	HNL	HNL				11	-2.1	-54.9			
13	HNL	HNL	11	HNL	HNL									
14	HNL	HNL												
15	HNL	HNL												

HNL = High noise level.

V. Dicussion Of Results

The plot the EM profiles conducted at AJagba, Asa, Ikonifin, Ikire-Ile and Baramoluare are presented in figures 3 – 7. The amplitude of the filtered and actual real EM anomalies in the study area varies from-79.1% to +0.8% and -2.4% to -37.9% respectively in Ajagba Locality (fig. 3), -26.9% to 47.1% and -42.6% to -55.4% respectively in Asa locality (fig. 4), -27.9% to -37.0% and -23.3% to 39.0% respectively in Ikonifin locality (fig. 5), -2.1% to 69.8% and -21.5% to -64.5% in Ikire-Ile respectively (fig 6). In Baramolu locality, the EM readings in most of the recording stations could not be recorded due to high noise level (from over head power cables) which overrode the EM signals. The amplitude of the filtered and actual real EM anomalies in the few stations recorded in this locality varies from -0.2% to 44% and -0.3 to 48% respectively (fig. 7).

The EM anomalies in all the localities in the study area are generally negative and devoid of any significant peak positive filtered real anomaly typical of subsurface structure. The typical negative EM amplitude anomalies observed in the study area are diagnostic of conductive overburden. The localization of groundwater in the study area will therefore be limited to the overburden layer as the underlying basement layer is generally devoid of subsurface structures.

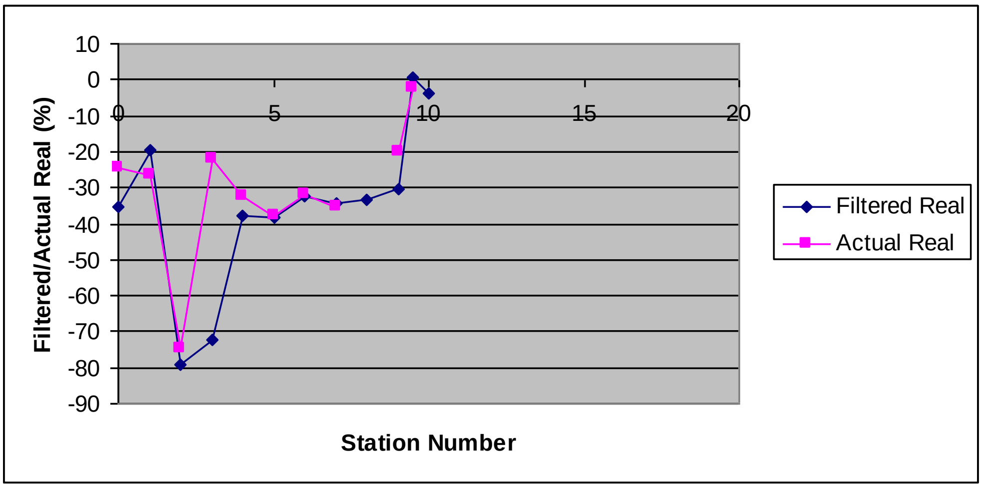

Fig. 3: WADI (VLF) Profile at Ajagba

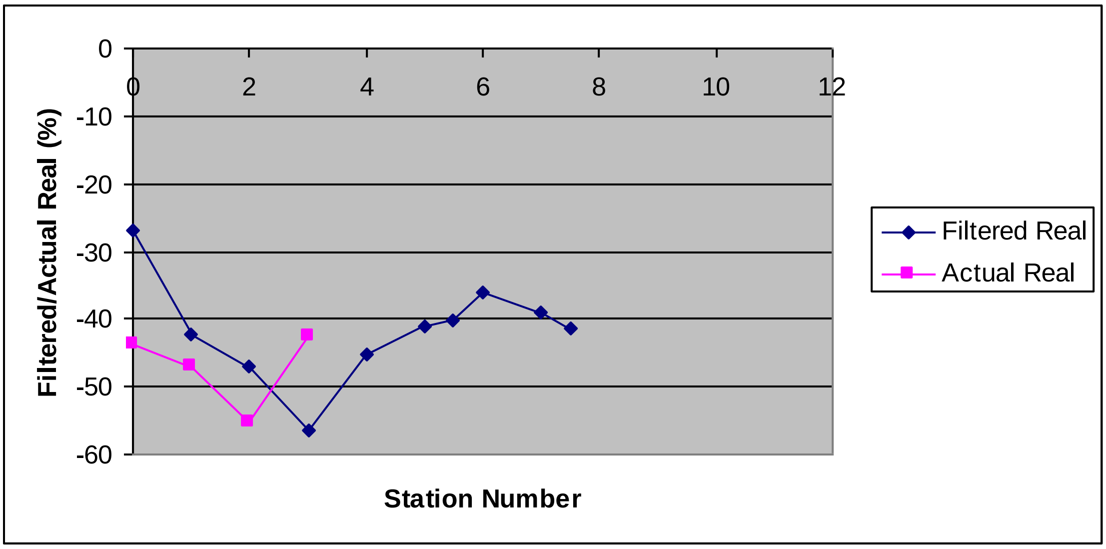

Fig. 4: WADI (VLF) Profile at Asa

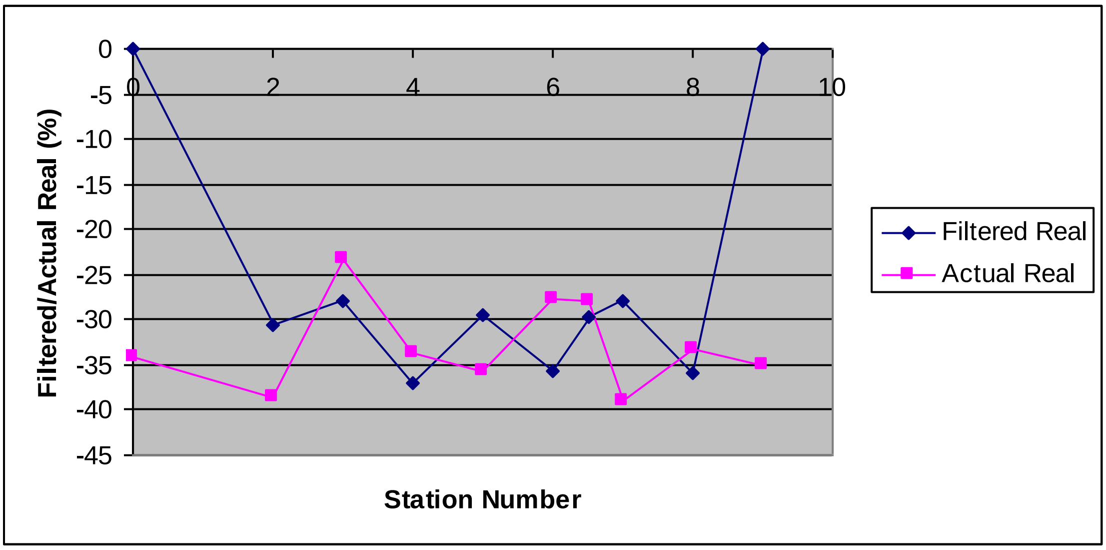

Fig. 5: WADI (VLF) Profile at Ikonifin

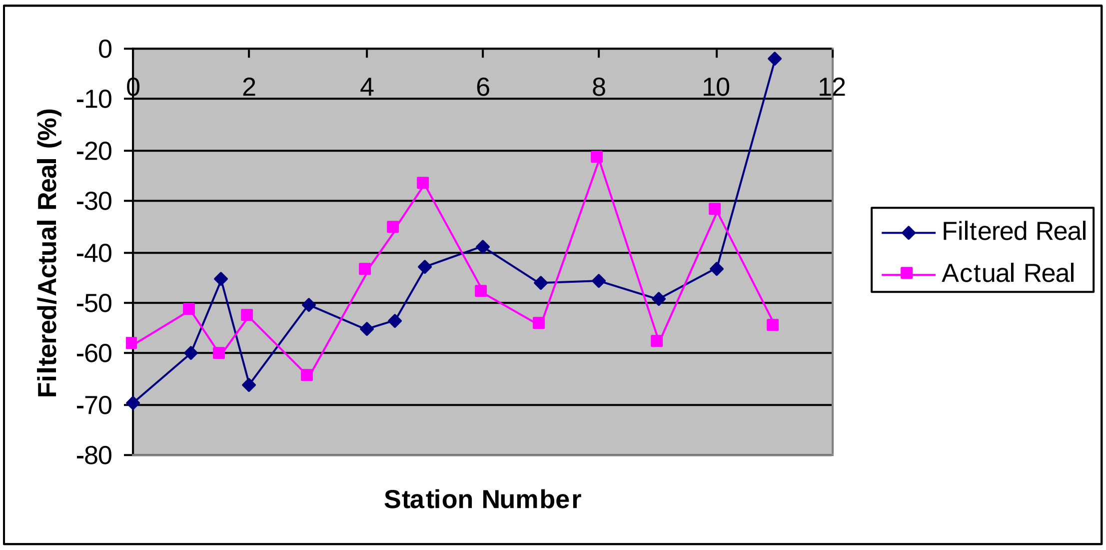

Fig. 6: WADI (VLF) profile at Ikire-Ile

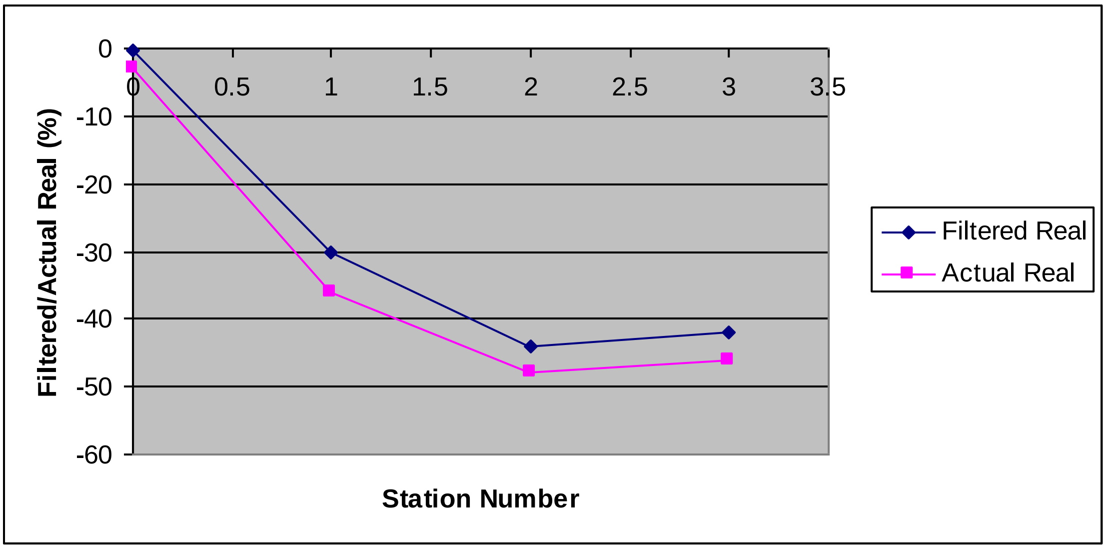

Fig. 7: WADI (VLF) Profile at Baramolu

VI. Conclusion

The EM survey reveals that the study area is generally devoid of subsurface structures such as fractures, joints and fault. The accumulation of groundwater in the study area will therefore be restricted to the overburden layer. The amount of groundwater that will accumulate within the overburden layer will depend on the thickness and lithology of the overburden.

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