ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 02, pp.1755-1764, February, 2019

DOI: https://doi.org/10.24941/ijcr.34432.02.2019

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

ELECTRICAL RESISTIVITY SOUNDING AND TOTAL MAGNETIC FIELD METHODS TO DETERMINE THE OVER BURDEN DEPOSITAND BED ROCK PHYSICAL PROPERTYFOR GROUND WATER POTENTIAL ASSESSMENT A CASE STUDY

***Birhan Muche Alemie**

Amhara National Regional State Water, Irrigation and Energy Bureau, Bahir Dar, Ethiopia

ARTICLE INFO

Article History:
Received 20th November, 2018
Received in revised form
18th December, 2018
Accepted 29th January, 2019
Published online 28th February, 2019

Key Words:
Bed rock; Electrical Resistivity Equivalence; Parameters Correlation, Total Transversal Resistance; Longitudinal Conductance and V-Transformation

ABSTRACT

The electrical resistivity sounding (VES) and magnetic profile methods are the most popular and the cheapest geophysical techniques. But the electrical resistivity sounding methods are more efficient for shallow deposit (sedimentary stratified layers) and not for the shallow and deeper volcanic rock horizon to delineate the bed rock due to erratic data and its electrical equivalence limitation. Here in this paper, It is attempted to show how magnetic profile could help the electrical resistivity sounding investigation. Electrical Resistivity Sounding and Total Magnetic Field Methods to determine the over burden deposit thickness and characterize bed rock physical property for ground water potential assessment. This approach can help to handle the bed rock geophysical property. To conduct investigation work on Gerado catchment: One magnetic profile crossing the catchment SE to NW direction which has 1820m profile length with 50m spacing and three electrical resistivity soundings with AB[m] = 1500m by using Schlumberger configuration had been carried out at the selected three stations on the magnetic profile. All VES data analysis, interpretation, 1D and 2D geo-electrical cross-section models of subsurface had been processed, determined and generated by using IPI2win and IX1D for electrical resistivity, Potent for magnetic modeling to fix top depth and to get a good picture of the bed rock under subsurface.

***Citation: Birhan Muche Alemie,* 2019.** "Electrical resistivity sounding and total magnetic field methods to determine the over burden depositand bed rock physical propertyfor ground water potential assessment a case study", *International Journal of Current Research*, 11, (02), 1755-1764.

INTRODUCTION

Gerado catchment is one of the main ground water potential areas in the vicinity of Dessie town. Now days at least five boreholes were drilled and all bores had been productive. The yield of the bore holes ranges from 6l/sec(Aquabilen) to 40l/sec(Pw4) and the depth of the five boreholes ranges from 59.43(pw1)m to 120.35m(pw2).The correlation coefficient of the discharge and depth values is 0.18.Which indicate that productivity of the well has not a strong relation with depth. Typical evidence can be observed two bore holes such as pw5 and Aquabilen with similar depth have three times discharge rate difference. In the same manner Pw2 and Pw4 have twice discharge difference. That is why this study had been conducted to identify the problems and to investigate further the geophysical property of over burden deposit and bed rock beneath it. To study this area, two universally important and low cost geophysical techniques applied. For particular study, one total magnetic field profile crossing the catchment SE to NW direction which has 1820m length with 50m spacing and three electrical resistivity soundings with AB[m] = 1500m had been carried out on the selected points on the magnetic profile which show different geophysical response.

The location and geology of the study area

Location of the study area: Tita is situated in the north eastern part of Ethiopia in the vicinity of Dessie district. It lies between [1225500, 1228000] latitude and [561000, 567000] longitude UTM coordinate system which has adindan Ethiopia datum Figure1 and 2 which can be accessed by asphalt road from Dessie to Combolcha.

Regional Geology of the study area: Ethiopia lies at the northern tip of the continental part of the East African Rift System. Voluminous piles of mainly Cenozoic volcanic rocks occur in large parts of western Ethiopia. The volcanic geology of North Western Ethiopia dates back to the Tertiary period of the Cenozoic era which divides the volcanic rocks of the country in to (i) The Trap Series and (ii) The Aden Series. The term Trap Series is still widely used to represent the whole pile of the Tertiary flood basalt sequence with intercalations of silicic rocks (commonly on the upper part) which form the northwestern and southeastern plateaus of the country and attain a thickness of up to 3km. However, recent studies have enabled to distinguish several volcanic episodes in the Trap volcanic rocks.

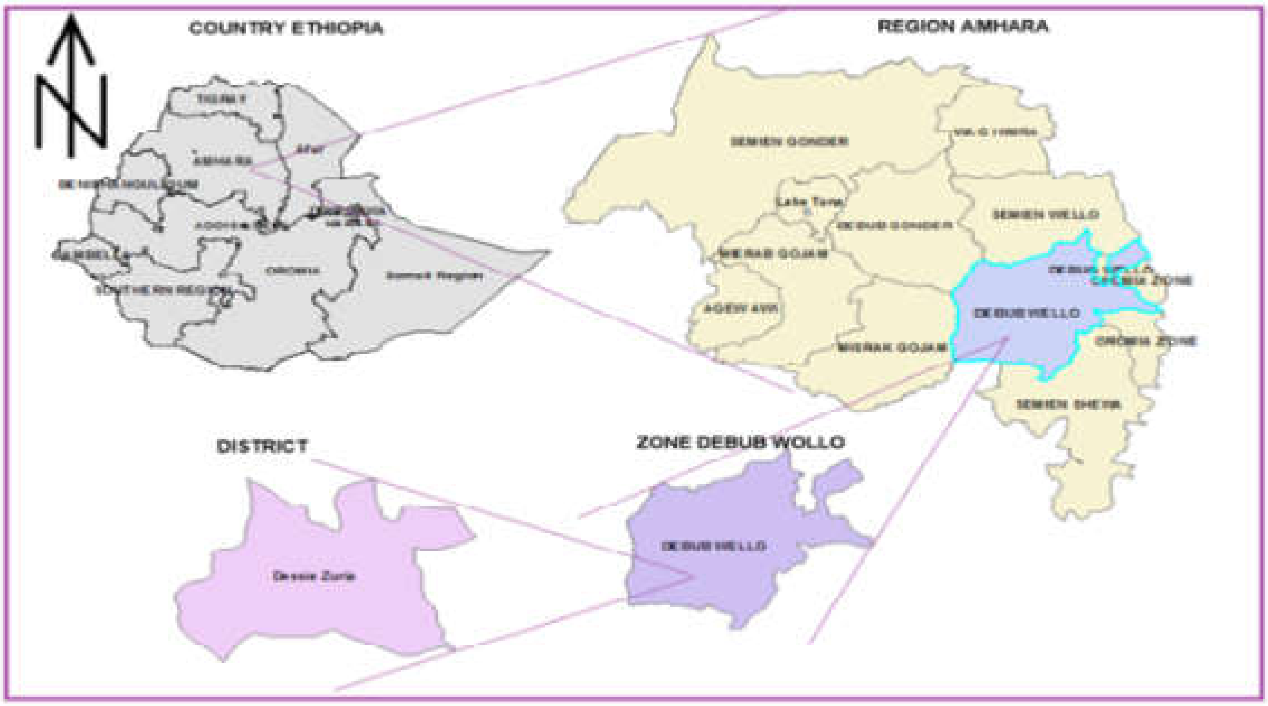


Figure 1. Geographical map of the study area

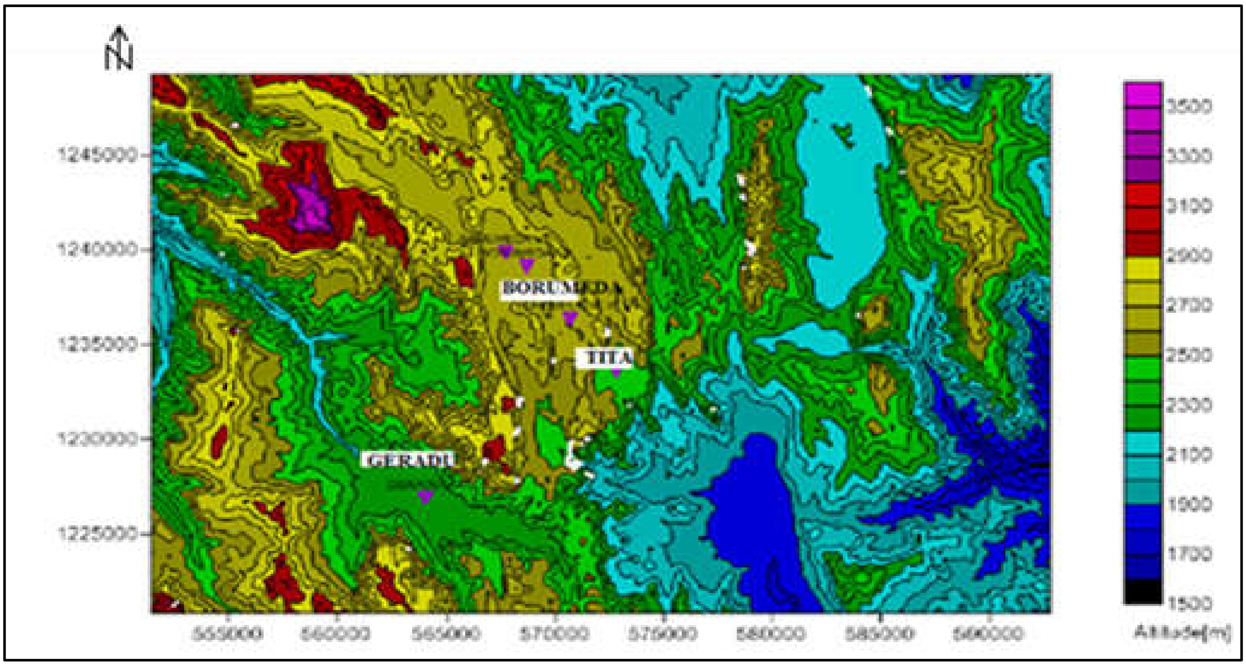


Figure 2. The contour map of the three main catchments in the vicinity of Dessie

The Cenozoic volcanic cover of the north western Ethiopia consists of the following major units: (i) Ashangie Basalts (ii) Aiba Basalts (iii) Alagie Formation and (iv) TarmaberGussa and Tarmaber-Megezez Formations (Mengesha *et al*, 1996)

Geological Structures: Three distinct structural patterns are known in the western margin of the rift. The NE – SW structures that parallel the Main Ethiopian Rift trend; the ENE -WSW trending structures that parallels the Gulf of Aden trend ; N – S trending border faults, the NNW – SSE oriented border faults and rift basin trends parallels the Red Sea Rift trend.

Hydrogeology: Hydrogeological studies include lithological, structural, geomorphological and hydrological studies. This should be supported with surface and subsurface geophysical investigations.

In hard rocks, fractures studies form an important component of field investigations. Hydrogeology encompasses the study of interrelationships of geologic materials with the coexisting natural water. It deals with the occurrence, movement and chemistry of groundwater. Groundwater in volcanic rocks occurs under perched, unconfined and confined conditions. Water under confined conditions may occur where the pervious lava beds are confined between impervious sedimentary beds or when the vesicular or fractured basalt is sandwiched between massive units. Acidic volcanic rocks, like rhyolites (in the study area it is found in most of Jiletimugaworeda), are usually more massive than basalts and therefore have lower porosity and permeability though some exceptions may occur.

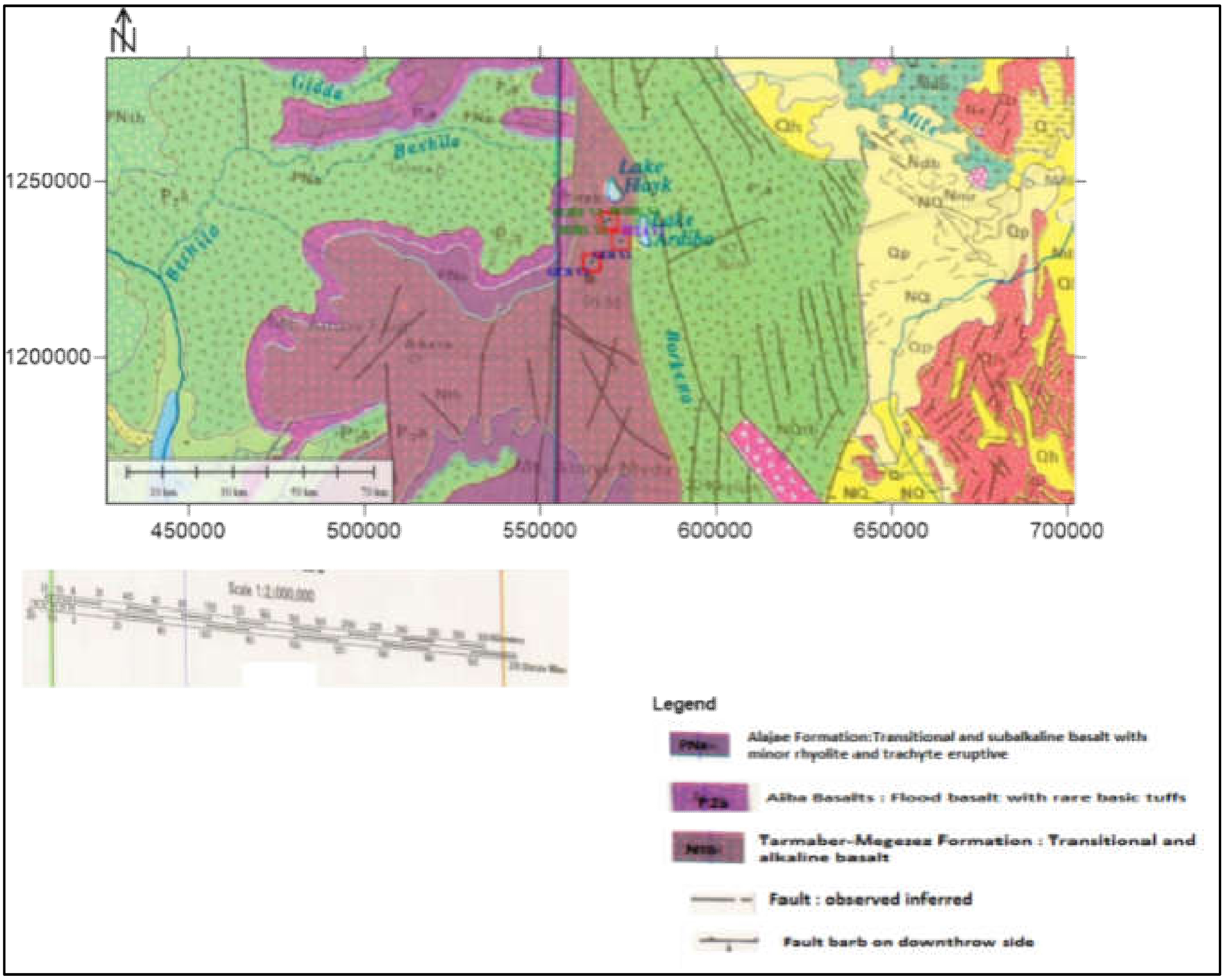


Figure 3. Geo-referenced geological map of the study area

The various openings which impart porosity and permeability to basaltic rocks are scoariae, breccia zones between flows, cavities between pahoehoe lava flows, shrinkage cracks, parallel to the flow surfaces or columnar joints, gas vesicles, lava tubes, and fractures and lineaments. Majority of the study area is covered by acidic volcanic rocks. They are of different geological ages, but the most common ones on the study area are of pre Oligocene to Oligocene-Miocene ages.

Local geology, hydrogeology and geological structures Gerado area

Local geology Gerado area: The major lithological units identified in the study area are volcanic rocks and alluvial deposits But there are also none mappablelithological units like thin paleo soil which is reddish in colour and highly compacted found at the contact between different lava flows and at the contact between ignimbrite and tuff.

Lower Basalt: *At the north western part of the study area, the basalt is found at the river bed overlained by ignimbrite. The basalt is black in colour, fine grained, moderately weathered, highly jointed and vertically fractured, where the dominant orientations of the fractures are N-S and NNE-SSW. The thickness of the basalt ranges from 20-25 m. From the stratigraphy observed in the study area, this rock is very* similar with Aiba basalt which is described in the regional geology.

Ignimbrite and Tuff: The ignimbrite is grayish pink in color, slightly weathered, jointed, vertically and irregularly fractured. The dominant orientations of the fractures are N-S and NNW-SSE. It is a coarse grained rock contains phenocrysts of quartz and feldspars and the thickness of this lithology ranges from 4-5m. The ignimbrite is found overlain by tuff and otherlithologic units and is highly exposed on the northwest and at the outlet of the Gerado river catchment. Some of the contact between ignimbrite and the underlying lower basalt observed at 2224m at a location of 1230300N/558595E and at (1231414N/557055E, 2468m above sea level. The tuff is whitish, highly weathered, horizontally, vertically and irregularly fractured. Its thickness ranges from 3-4 m. It is found exposed in the north western parts of the studied area. At the contact between tuff and the underlying ignimbrite, the color of this lithology is becoming bluish to whitish due to the out coming of water at the contact.

Upper Basalt: The third main lithologic unit overlying the ignimbrite and tuff is the upper basalt having more than two lava flows, where the first one is highly weathered, grayish black in colour, moderately to coarse grained, highly fractured and overlain by unweathered and highly fractured basalt. Thecontact between the underlying lithology and the upper basalt observed at 2224m elevation at a location of

1230300N/558595E. The second lava unit overlying the highly weathered and fractured basalt is unweathered, blackish in colour, highly fractured, and phenocrysts rich basalt, where the phenocrysts are feldspars with size ranging from minute to 8mm. The fractures found in these lithologic units are vertical and irregular in nature. This geological formation also highly exposed continuously from Dessie southwards to Tossa Felana and the road from Dessie to Kombolcha. The basalt has a thicknessranges from 80-100.

Alluvial Deposit: This unit is exposed on the flat, and flat to gentle part of the study area. From field observation and lithologic log of the boreholes found in the flat land, composed of black cotton clay, silt, sand, rounded gravel and boulders. The thickness of the alluvium can reach up to180m.The alluvial deposits are becoming fine grained at the center of the catchment whereas at the base of the surrounding mountains and along the river courses, the deposit becomes coarse grained and sub-rounded and angular in shape.

Local hydrogeology: Hydrogeology encompasses the interrelationship of the geologic material and the processes with water (Fetter, 1994). It deals with the occurrence, distribution, and movement of ground water in addition to physical as well as chemical relationship with the surrounding environment. Hydrogeology is the area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the earth's crust, commonly in aquifers. Meinzer (1923) defined an aquifer as a geological formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs. An aquifer is a geologic formation that has the ability to store and transmit water. An aquifer is a body of rock that can store and transmit significant quantities of water (Gunn, 2004). These characteristics vary according to porosity and permeability of the material. Porosity is the percentage of open space in a rock. Permeability is the degree to which a rock allows the transmission of fluids through these pore spaces. Even if a rock has high porosity and contains water, it is not considered an aquifer unless it has high enough permeability to get the water out. Gerado area aquifers with intergranular porosity and permeability are highly exposed on the flat, gentle to flat and gentle land of the study area. From surface and subsurface information, it is dominantly composed of clay, sandy clay, silt, silty sand, sand, gravel and boulder and of the catchment. In this aquifer the media which is so vital for the storage and transmission of water through grains of the aquifer is the interconnectivity nature of the space found between grains which lead to have intergranular porosity and permeability.

Aquifers with inter granular and fracture porosity and permeability are highly exposed on North West and the steep slope of the study area. Since the weathering and fracturing degree of the formation is highly intensive; some part of the formation is becoming easily friable, crushed and easily detached from the parent material .This nature of the formation allows the water to store and transmit through the crushed and friable part of the rock, which leads to have inter granular porosity and permeability aquifer. In addition, in these formations fracturing is also the main determinant factor for the storage and transmission of water which leads to have fracture porosity and permeability. The weathering effect in these geological formations is insignificant, whereas the fracturing rate is highly pronounced. As a result, the media which could have significant role in the storage and transmission of water in the rock is due to the presence of these fractures, which makes the aquifer to have fracture porosity and permeability.

Generally the aquifers of the study area:

- Alluvial deposit
- Highly weathered and fractured basalt and tuff
- Fractured basalt and tuff

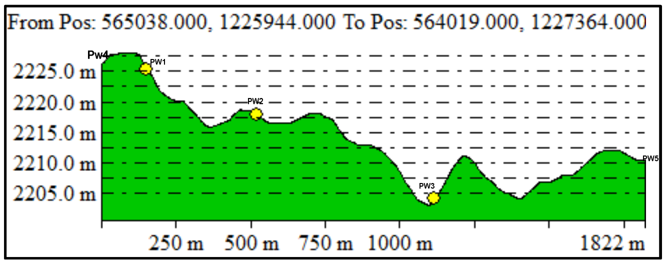


Figure 4. Profile line of Gerado wells

Table 1. Gerado hydrogeological inventory data

Gerado Hydrogeological inventory data							
Borehole name	Easting	Northing	Elevation	Well depth	SWL	Discharge l/s	Remark
Pw1	565082	1226087	2225	59.43	0	30	
Pw2	564864	1226388	2221	120.35	0	20	
Pw3	564421	1226782	2218	109.12	0	12	
Pw4	565038	1225944	2227	120	0	40	
Pw5	564019	1227364	2210	80.87	0	17	
Aquabilen				80	-	*6*	

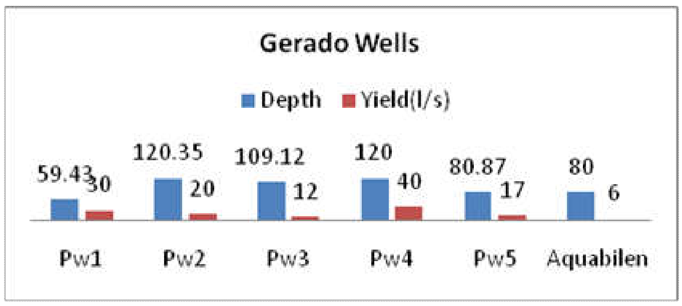


Figure 5. Grado wells Chart of depth and yield

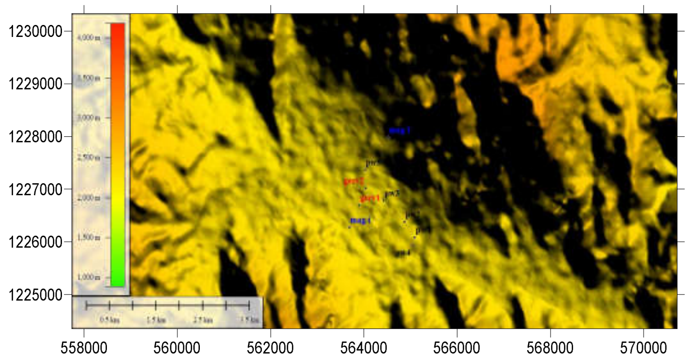


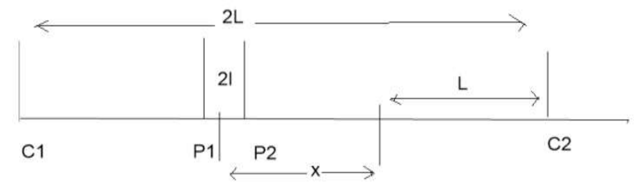
Figure 6. Wells, VES points and Magnetic profile line illustrative map

MATERIALS AND METHODS

The geophysical instruments used in this study are two types. The first type is Canadian Scintrex EVI VLF Proton precession magnetometer and the second type is Swedish ABEM

Terrameter LS conventional resistivity. Land base total magnetic field measurements and Schlumberger array vertical electrical soundings are the two important geophysical techniques that had been used to explore subsurface. Geo-electrical resistivity techniques are popular and successful geophysical exploration to study ground water conditions in the world. The resistivity of materials is depending on many factors such as ground water, salinity saturation, aquifer lithology and porosity. When the aquifer electrical conductivity is high, the resistivity of aquifer could reach the same range as clayey medium and the resistivity parameter is no longer useful to determine aquifer. However this method has been carried out successfully for the exploration of ground water and to determine the depth and the nature of an alluvium, boundaries and location of aquifer.

The solution for Schlumberger spread when $x = 0, r_1 = r_4 = L - l, r_2 = r_3 = L + l$ is



Schlumberger array

$$\rho_a \approx \rho_1 \left[1 + 2\sum_{m=1}^{\infty}\left[\frac{k^m}{\{1+(2mz/L)^2\}^{3/2}}\right]\right] \text{.................................(1)}$$

$$\rho_1\left[1 + 2D_s'\right] \text{..(2)}$$

To determine B magnetic induction vector on surface of the earth we have to carry out harmonic analysis of the observed data. The scalar magnetic potential caused by current inside the earth can be expressed

$$V_M^{inside} = R\sum_{n=1}^{\infty}\sum_{m=0}^{n}\left(\frac{R}{r}\right)^{n+1} P_n^m(\cos\theta)\left[g_n^m.\cos(m\lambda) + h_n^m.\sin(m\lambda)\right] \text{....................(3)}$$

Where r,θ and λ are the geographic sphere coordinates, radial distance, colatitude and eastern length. By using this scalar magnetic potential function the ambient theoretical magnetic field can be calculated.

Data acquisition and interpretation: Canadian Scintrex EVI VLF Proton precession magnetometer geophysical instrument had been deployed to carry out total magnetic field measurement along a profile from SW part to NE direction. Theoretical magnetic field value of Gerado is calculated, which is equal to

F=36344nT, D=2.386^o East and I= 7.78^{o}Down

These values are essential parameters to measure accurate magnetic field values. The Scintrex has a special configuration to explore different tasks such as archaeological, mineral, oil and water. This adjustment for different exploration purpose was applied for ground water investigation purpose. In this investigation, total magnetic measurement for groundwater was selected. The data collected is plotted on Figure 5. In addition to Scintrex the latest instrument Swedish ABEM Terrameter LS which could measure voltage drop in micro volt with high accuracy had been deployed to carry out resistivity measurement at three different points selected from magnetic profiling.Gerav1 is conducted at high magnetic response 36761nT at a point 465m, at near median magnetic response GeraV2 36673nT 811m at a point from initial position and at the smallest magnetic response Gera V3 36223nT at apoint 1400m.

DISCUSSION OF THE RESULTS

The magnetic field data had been analysed by using Australians potent version 4.09 2 demo mode magnetic processing software and the resistivity field data had been analysed by IX1Dv2.2Interpex limited Golden Colorado USA licensed software and Moscow state of university freeware IPI2win (2008).These are most powerful soft ware's and highly interactive. Potent can provide a lot of mathematical models but with two subsets for demo mode. In this study limitations did not affect this work. Because the bed rock striking direction and thickness estimation were determined by pseudo-section vertical derivative transformation. So the only task was to get the possible bed rock structure which resembles the shape of pseudo-section of vertical derivative transformation. To make the task to be clear and simple for the reader, the discussion of the results were described as Qualitative analysis and interpretation, semi qualitative analysis and interpretation and Qualitative analysis and interpretation.

Qualitative data analysis and interpretation

The magnetic field data: The magnetic field location data were recorded in UTM coordinate system & datum is Adindan Ethiopian Cartesian system as [x, y, z] as shown below. From [563680, 1226283, 2283] to [564521, 1227989, 2257] which has a length of 1850m with 50m spacing. The data is plotted in the figure 8 indicates that two different response at 250m has high response and 1400m has low response. Even though interpretation made by magnetic method is the most complex geophysical method. It is possible to retrieve information from graph that along a given profile, polygonal prism model can be generated. From the magnetic profile three different peaks values are selected to conduct and distinct catchment based on the result of geophysical resistivity responses that three vertical electrical sounding GeraV1, GeraV2 and GeraV3 Schlumberger configuration conducted. Having different magnetic response on this profile, the vertical electrical resistivity sounding (VES) stations could be easily located. So that upper peak I for GeraV1, GV2 and lower peak II for GeraV3. In addition to VES stations selection, simple observation on the graph, the residual magnetic anomaly could be used to delineate the shallow surface geological structure such as at point' A' could be response of the thin dike structure near to surface stream, at point 'B' very shallow river structure on the surface.

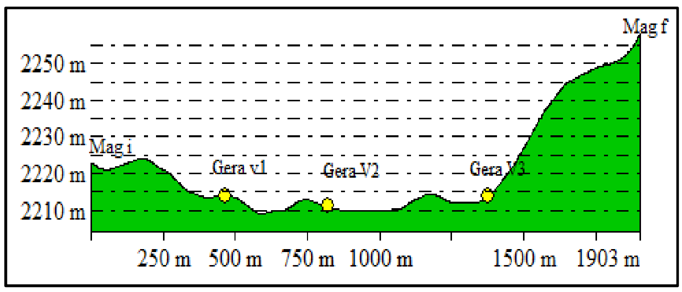


Figure7. Profile line of magnetic survey

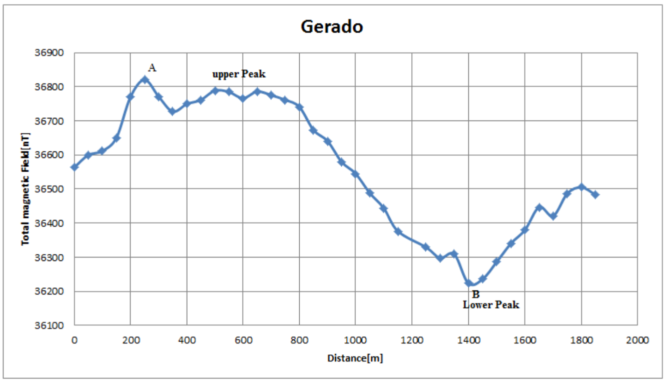


Figure 8. Total magnetic field data graphic representation

Pseudo geo-electrical section: Based on the result from magnetic profiling, vertical electrical resistivity soundings (VES) Gera V1, GeraV2 and GeraV3 had been conducted. Pseudo-section of the VES data points was plotted as shown in figure 9. Pseudo-section indicates that the apparent resistivity values increased with depth in both SE and NW parts of the pseudo-section. Shallow depth of pseudo-section could be the response of unconsolidated alluvial deposit which may be one of thick portion of pseudo-section at pseudo-depth≥ 350m in SE and≥ 150m.

In addition high apparent response could be response of basement rocks.

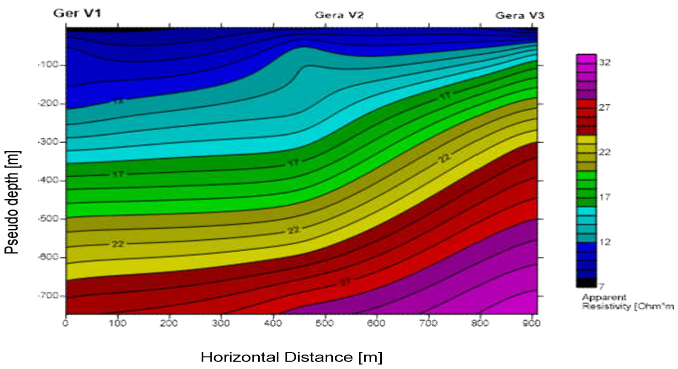


Figure 9. Geo-electrical pseudo-section of the study area

Semi qualitative data analysis and interpretation: Pseudo-section vertical derivative transformation values were calculated from best fit regression polynomial degree six graph and the result values are plotted by Surfer version 10.2.601(32 bit) Apr6, 2011 software licensed. The polynomial best fit for apparent resistivity calculated and its gradient valuedetermined.

V.d.t=vertical derivative transformation

Since vertical derivative transformation indicates the inflection points of the pseudo-section, its section parts have similar pattern as geo-electrical section as shown in the figure 10. So that understanding pseudo-section vertical transformation can help interpreter to handle both geo-electrical section shown in figure 11and magnetic model shown in figure 12. Because in resistivity analysis and interpretation ,most of graphs have not clear inflection point special at deeper AB/2 and as result it could difficult to determine the bed rock response due to complex equivalent models problem. But if the vertical derivative transformation is computed, it could provide likihood values and shapes of the bed rock.

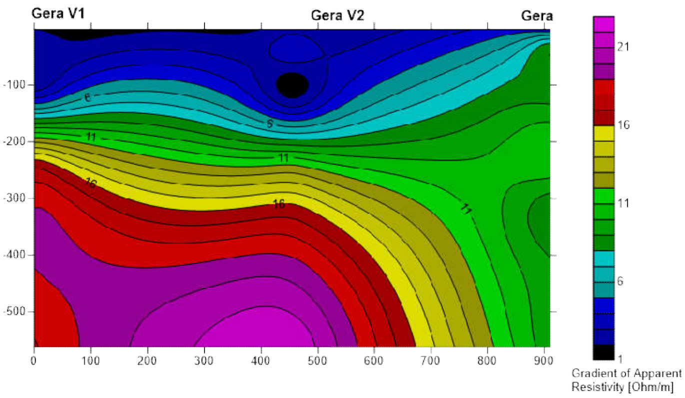


Figure 10. Pseudo-section of vertical derivative transformation

***Quantitative data analysis and interpretation*:** GeraV1,GeraV2 VES and GeraV3 data have been analysed and interpreted by IX1Dv2.2 and IPI2win (2008) softwares by correlated the local geology, magnetic graph and pseudo-section vertical derivative transformation. The field data GeraV1, GeraV2 VES and GeraV3 are inverted to get model parameters that could determine geophysical property subsurface of the earth. To get the best fit curves and models parameter with high resolution matrix repeated iteration of processing data is required. One of the limitations of geophysical interpretation is non-unique solution for unique field data curve. Equivalence and suppression are most known problems in three model inversion approaches.

Equivalence: There are two types of equivalence problems in electrical resistivity sounding techniques.

S-Type Equivalence: *This occurs when the middle layer is low resistive that is H-type curve. The current focuses to flow parallel to the middle layer. The ratio of*

$$S = {}^{h}\!/_{\rho} = cons\tan t....................(7)$$

T-Type Equivalence: *This occurs when the middle layer is high resistive that is T-type curve. The current focuses across to the middle layer. The product of*

$$T = h\rho = cons\tan t...................................(8)$$

Suppression: This occurs when the curve type is either A-type or Q-type. Thin layer effect should be considered in interpretation process.

Resolution matrix

The resolution matrix is the product of generalized inverse and Data kernel. The resolution matrix could attribute information how far the data is processed in accurate geophysical approach. $R = G^{-g}G$; R-Resolution matrix-g-Generalized inverse data kernel and G-Data kernel Figure 14 and Figure 15 show that the 1D interpreted resistivity model,

Geophysical data inversion

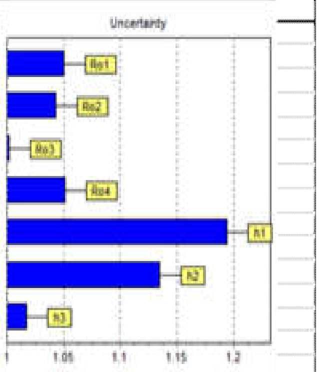
Weighted damped least squares: If the equation Gm=d is slightly underdetermined, it can often be solved by minimizing combination of prediction error and solution length, $E+\varepsilon^2 L$ .The parameter ε is chosen by trial and length error to yield a solution that has areas on small prediction error. The estimate of the resolution is then,

$$m^{est}=\langle m\rangle+\left[G^T W_e G+\varepsilon^2 W_m\right]^{-1} G^T W_e\left[d-G\langle m\rangle\right] \quad (9)$$

It should be analysed whether the inverse actually exist or not. Depending on the choice of the weighting matrices, sufficient a priori information should be added to the problem to damp the under determinacy. Gerado VES points have the following parameter bound.

Table 2. Equivalent model analysis and parametric correlation of Gera V1

Gera V1	Fitting error% = 1.52			
The analysis of the equivalent models: Limit				
N	p	K	Min	Max
Ro1	8.42	1.05	8.01	8.86
Ro2	5.58	1.04	5.3	5.78
Ro3	10.2	1	10.2	10.2
Ro4	66	1.05	62.7	69.4
h1	0.665	1.19	0.557	0.794
h2	2.02	1.14	1.78	2.29
h3	191	1.02	188	194
Z1	0.665	1.19	0.557	0.794
Z2	2.68	1.1	2.44	2.96
Z3	194	1.02	190	197

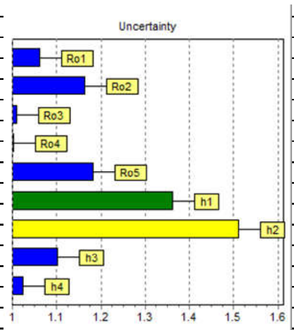


Correlation

	Ro1	h1	Ro2	h2	Ro3	h3	Ro4
Ro1	1	-0.93	-0.68	0.33	-0.09	0.01	-0.01
h1	-0.93	1	-0.56	0.09	0.06	-0.02	0.01
Ro2	-0.68	-0.56	1	0.85	-0.29	0.02	-0.02
h2	0.33	0.09	0.85	1	0.46	-0.06	0.05
Ro3	-0.09	0.06	-0.29	0.46	1	0.59	-0.49
h3	0.01	-0.02	0.02	-0.06	0.59	1	0.95
Ro4	-0.01	0.01	-0.02	0.05	-0.49	0.95	1

Table 3. Equivalent model analysis and parametric correlation of Gera V2

Gera V2	Fitting error% = 1.23			
The analysis of the equivalent models: Limit				
N	p	K	Min	Max
Ro1	9.47	1.06	8.9	10.1
Ro2	6.02	1.17	5.17	7.02
Ro3	11	1.01	10.8	11.1
Ro4	13	1.01	13	13.1
Ro5	162	1.19	137	192
h1	0.687	1.36	0.504	0.937
h2	1.19	1.51	0.788	1.8
h3	12.7	1.1	11.5	14.1
h4	271	1.03	264	277
Z1	0.687	1.36	0.504	0.937
Z2	1.88	1.33	1.47	2.49
Z3	14.6	1.09	13.4	15.9
Z4	285	1.02	278	292



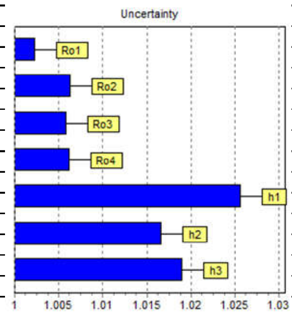
Correlation

	Ro1	h1	Ro2	h2	Ro3	h3	Ro4	h4	Ro5
Ro1	1	-0.91	-0.76	0.51	-0.23	0.05	-0.02	0.01	-0.01
h1	-0.91	1	-0.55	0.19	0.09	-0.08	0.04	-0.01	0.01
Ro2	-0.76	-0.55	1	0.92	-0.54	0.13	-0.05	0.01	-0.01
h2	0.51	0.19	0.92	1	0.74	-0.24	0.1	-0.03	0.03
Ro3	-0.23	0.09	-0.54	0.74	1	0.67	-0.3	0.05	-0.04
h3	0.05	-0.08	0.13	-0.24	0.67	1	0.76	-0.44	0.41
Ro4	-0.02	0.04	-0.05	0.1	-0.3	0.76	1	0.71	-0.62
h4	0.01	-0.01	0.01	-0.03	0.05	-0.44	0.71	1	0.98
Ro5	-0.01	0.01	-0.01	0.03	-0.04	0.41	-0.62	0.98	1

Geo-electrical section Representation and Interpretation: Geo-electrical section indicates in Figure 11 that fourth layers are identified in both SE and NW parts. The first and second layers SE part section(GeraV1) has best estimated averaged thickness 3.58m and true resistivity ≤10Ωm which could the response of clay deposit and/or third layer which could be the response of alluvial deposit and/or highly decomposed and weathered basalt (rhyolite) saturated with water.

Table 4. Equivalent model analysis and parametric correlation Gera V3

Gera V3	Fitting error% = 0.645			
The analysis of the equivalent models: Limit				
N	p	K	Min	Max
Ro1	6.42	1	6.4	6.44
Ro2	8.91	1.01	8.85	8.96
Ro3	18.3	1.01	18.2	18.4
Ro4	36.9	1.01	36.7	37.1
h1	2.07	1.03	2.02	2.12
h2	11.3	1.02	11.1	11.5
h3	100	1.02	98.5	102
Z1	2.07	1.03	2.02	2.12
Z2	13.3	1.01	13.2	13.5
Z3	114	1.02	112	116



Correlation

	Ro1	h1	Ro2	h2	Ro3	h3	Ro4
Ro1	1	0.71	-0.44	0.16	-0.09	0.03	-0.02
h1	0.71	1	0.88	-0.56	0.36	-0.15	0.1
Ro2	-0.44	0.88	1	0.78	-0.46	0.16	-0.1
h2	0.16	-0.56	0.78	1	0.79	-0.38	0.26
Ro3	-0.09	0.36	-0.46	0.79	1	0.77	-0.55
h3	0.03	-0.15	0.16	-0.38	0.77	1	0.88
Ro4	-0.02	0.1	-0.1	0.26	-0.55	0.88	1

The fourth layer is relatively which has true resistivity 66Ωm from figure 15.The first and second layer of the central part of the section (GeraV2) has range from 0.687 to 1.19m thickness and from 6.02 to 9.47Ωm true resistivity which could be the response of clay deposit. The third and fourth layers have range from 11Ωm to 13Ωm true resistive which have range from 12.7m to 271m thickness and the fifth layer has 162Ωmtrue resistivity in figure 16.The first and second layers NE part section (GeraV3) has best estimated range thickness 2.07 to 11.3m and 6.42 to 8.91Ωm true resistivity and 100m thickness which could the response of clay deposit, alluvial deposit and/or highly decomposed and weathered basalt (rhyolite) saturated with water.

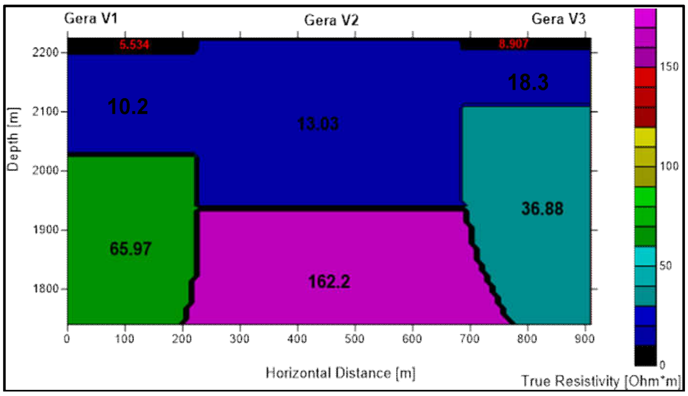


Figure 11. Slightly smoothed layered Geo-electrical section of Gerado VES points [ρ,h] is the order of parameters in Figure 8

The fourth layer has true resistivity 36Ωm. The equivalent model table2-3 indicates that equivalent model of GV1, GV2 and GV3 have k value 1-1.19, 1.01-1.36 and 1-1.03 respectively. From those results, the equivalent model have not significant affected the interpretation. The parametric correlation table 2-3 indicates that equivalent model of GV1has R_o-h_1, Ro2-h_2, Ro4-h_3 have correlation values -0.93, 0.85 and 0.95 respectively. From those results, among of model parameters R_o-h_1, Ro2-h_2, Ro4-h_3 pairs were not well resolved and need other geological plausible a prior information.

Magnetic model presentation and Interpretation: The data quality of total magnetic field has high accuracy with high signal/noise ratio. The ripples on the magnetic field profile plot are due to very near surface of the study area which are at station 250m and station 1400m.The depth of magnetic model section has a range between 0m and 209m. The SE vertex of section has depth of 0m as shown in figure 12.Unlike aeromagnetic method, ground base magnetic method data measurements are dominated by the effect of the shallow geological formation. So that shallow model could have geological plausibility. The magnetic susceptibility along the width(y) $\chi_A = 0.0221SI$ which could be the response of decomposed, highly weathered volcanic rock formation and which could be magnetized by prevailing geomagnetic field attribute to total magnetic field $F\cos I$ and the magnetic susceptibility along height (Z) $\chi_C = 1.0678SI$ which could be the response mafic olivine minerial volcanic rocks.Since magnetic susceptibility $\chi = \frac{\Delta B}{B_o}$ becomes positive where B_o is the inducing magnetic field [1,9].The magnetic model section of Gerado study area could have three layers.The first layer has the thickness ranges from 0m to 209m SW part section could have clay,clayey sand.The second layer could have thickness of 123m. SW part of section could have decomposed,highly weathered basalt and NE part of the section could have gravel.The third layer could not be detected by this investigation works which could be dominated by the second layer magnetic field in Table 5.

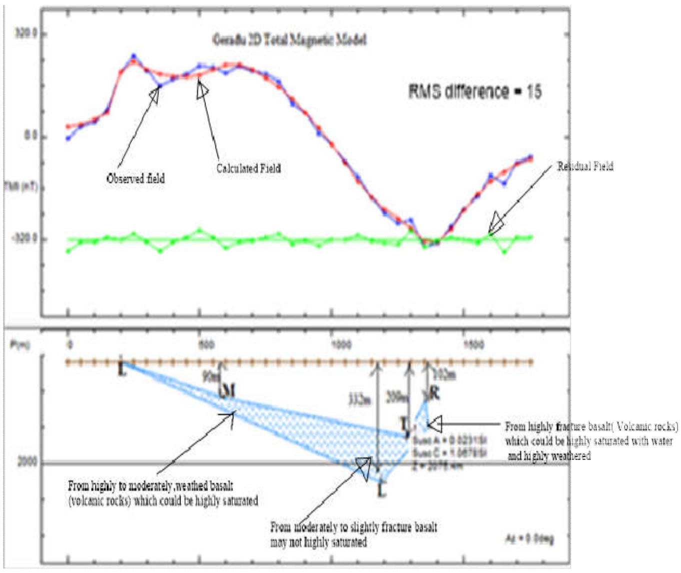


Figure 12. 2D Magnetic Field model of the study area

Darzarouk function and Variable Representation and Interpretation

Transversal resistance: *In figure13 transversal resistance of SE part of section is 2,000Ωm^2 which could be response of moderate/slightly fractured basalt at 194m depth, middle section (Gera V2) is 3,500m^2 at depth 274m which could be the response of slightly fracture volcanic rock and Transversal resistance of NW part of section (GeraV3) is 2,000Ωm^2 which could be the response of moderate/slightly agglomerate fractured basalt at depth 100m. This indicates that that pure basalt could have higher transversal resistance than slightly agglomerated basalt.*

Longitudinal conductance: In figure 14 longitudinal conductance at SE part section is 21 Siemen and thickness of the clay is 2.68m, the middle section (Gera V2) is 22 Siemen and14.6m thicknesses whereas NE part of section is 13 Siemen and thickness of clay is 13.3m. From the above description it is possible to correlate *transversal resistance* with the physical and chemical property of bed rock and the longitudinal conductance and the over burden thick of the clay may have direct relation. At GeraV2 the bed rock could be more harder and thickest deposit at Gera V2.

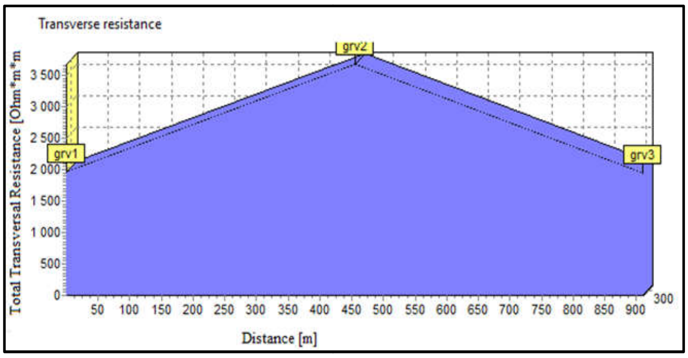


Figure 13. ***Transversal Resistance*** **of Gerado VES points**

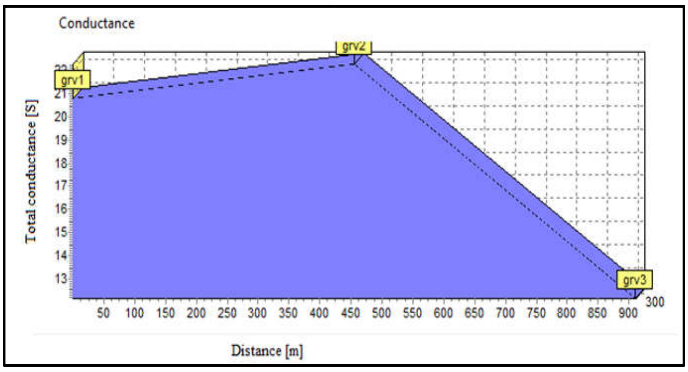


Figure 14. Longitudinal conductance of Gerado VES points

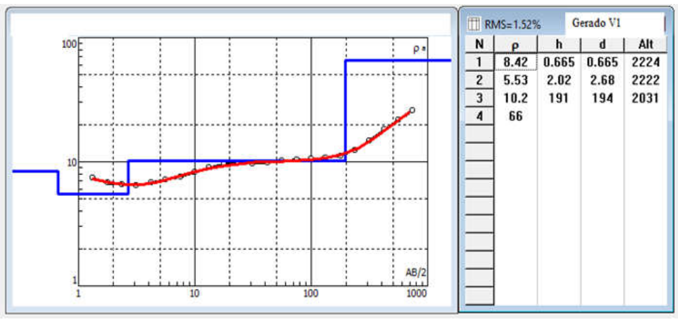


Figure 15. GeraV1 interpreted resistivity model of subsurface (HK model type)

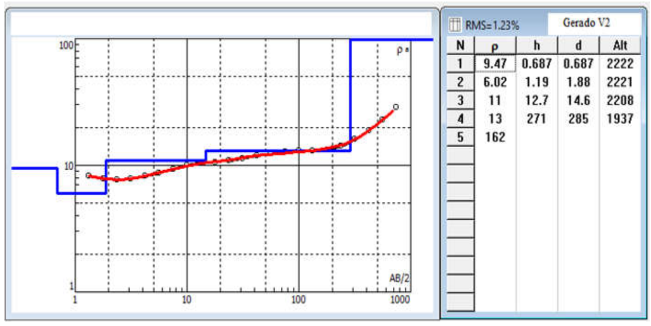


Figure 16. Gera V2 interpreted resistivity model of subsurface(HAA modeltype)

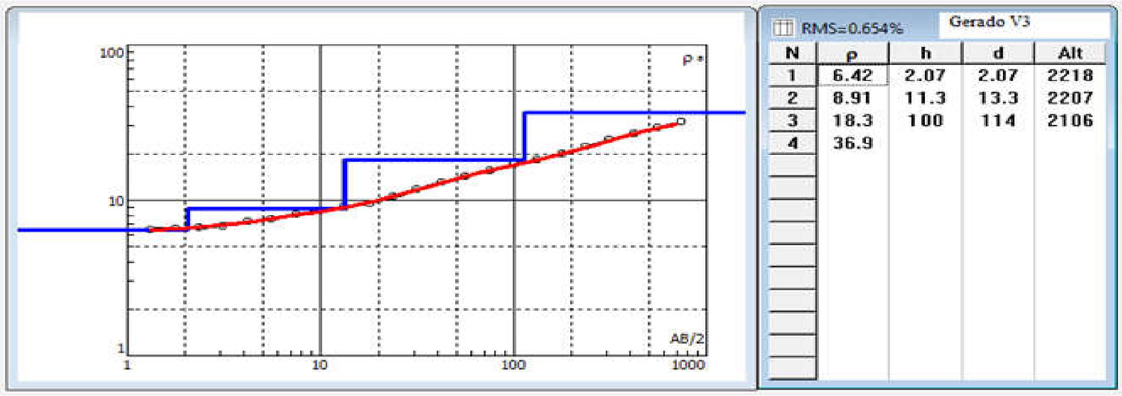


Figure 17. Gera V3 interpreted resistivity model of subsurface

LIthologic Description

Drilled Depth(m)		Lithological Description	Thickness	Type of formation	Remark
From	To				
0	2	Top soil	2		
2	26	Clay	24		
26	40	Sand+gravel+boulder	14		
40	54	Sand +clay dominated	14		
54	66	Sand + more gravel	12		
66	70	Gravel with some sand	4		
70	78	Gravel with clay	8		
78	88	Boulder+gravel+sand+clay	10		
88	106	Boulder+gravel+with some sand	18		
106	110	Boulder with sand	4		
110	112	Clay	2		
112	132	Boulder+gravel+sand	10		
132	142	Boulder+gravel+sand with clay	10		
142	150	Clay	8		
150	158	Fractured basalt	8		
158	162	Weathered and fractured basalt	4		
162	174	Moderately fractured and slightly weathered basalt	12		
174	176	Highly weathered basalt	12		
176	182	Weathered basalt	6		
182	200	Highly fractured rhyolite	18		
200	208	Fractured and rhyolite	8		
208	212	Highly weathered rhyolite	4		
212	226	Moderately fractured basalt	14		
226	232	Weathered and fractured basalt	6		
232	300	Fractured basalt	68		

Address: Main office Bahir Dar, Laizon office Kombolcha, P.O.BOX 173, Phone -0582204736/68

Table 5 Lithological description

Conclusion

The SE part of 2D total magnetic field model section and GeraV1 model indicates that overburden deposit thickness are ≤90m and 194m respectively this discrepancy is due to magnetic susceptibility of the rock could not be affected by its physical property change like resistivity, middle section the over deposit thickness are between [90m, 209m] and285m respectively and NW part of magnetic model section and GeraV3 indicate that the over burden thickness are 102m and 114m respectively. Those results show that both methods can resolve the over deposit with 0.83 correlation value. The magnetic susceptibility values along SE strike is 0.23SI which could be response of fractured basalt and 1.01SI which could be the response of slightly fractured mafic olivine rich volcanic rock. The Vertical derivative transformation of Gerado cross section indicates that overburden thickness decrease from SE to NW and the bed rock thickness increase and harder from SE to the mid-section. The NW end section of cross section indicates that weak zone which could be fault zone is being dominated. It is possible to correlate *transversal resistance* with the physical, chemical property of bed rock and the longitudinal conductance with the over burden thickness of the clay formation of subsurface.

Limitations of the study

Even though the signal/Noise ratio of the magnetic profile data from SE to NW was with high accuracy, it was difficult to conduct along bisecting direction of magnetic profile SW to NE due to river crossing catchment .As a result of this, the susceptibilities of subsurface were calculated only along the width and height and additional Electrical resistivity sounding stations were not able to conduct to carry.

Recommendation

Vertical electrical resistivity sounding method is very important geophysical technique when it is integrated with total magnetic field profile field method. Vertical derivative transformation pseudo-section is used to determine the likihood shape of the bed rock and being highly sensitive to resistivity change could be able to delineate fracture. The residual magnetic field profile plot could provide information about the possibility of raw resistivity field data quality due shallow fracture effect of the study area. Proton precession magnetometer which is used in this study could detect shallow fracture saturated with water, so it could attribute to determine the optimum amount current which could be required in the complex volcanic terrain geological formation. It is important to generate pseudo-section of V.D.T. and ground base total magnetic model to correlate and control misinterpretation of VES due to electrical equivalence problems and suppressions. In addition it is better to generate *Transversal Resistance* and longitudinal conductance sections to understand over burden clay thickness, protective, capacity and the top depth of bed rock.

Acknowledgments: I would like to express my gratitude to my family Gezatu Adugnae & Enku Nega who give sponsorship to pay the expense of publication fee for this and the previous publication works and encourage me procced my study, ANRS Water Energy and Irrigation Bureau which provided me the latest instrument for my work , encourage me to work hard in this study area and Water Drilling Enter Prise which delivered me well drilling results. It is also my pleasure to thank full and demofree software provider such as Geophysical Software Solution Potent V4.09 Australia Pty.Ltd for magnetic modeling and Alexey Bombachew Mosco state university IPI2Win for electrical resistivity interpretations modeling.

REFERENCES

Alan M, MACDONAL, Jeff DAVIES & Ronger C, CaLOW."African hydrogeology and rural water supply".British geological survey.

Alexei A. Bobbachev, Igov.N, Modin,Vladimir Shevnin. IPI2Win User Guide. Mosco:Geoscan-M Ltd, 2001, pp.4

Genet Abera and Birhan Muche."Hydrogeological and Geophysical ground waterreport for Dessie water supply and swerage service (Tita,Borumeda and Gerado)". 2006,pp.4-20

Geological survey of Ethiopia."Georef-geo-map of Ethiopia Scale:1:2,000,000".

Geological Surveys of Ethiopia. "Geology of Ethiopia".1999.

Gholam R. Lashkripour and Mohammad Nakhaei. "Geoelectrical investigation for the assessment of ground water conditions:a case study". Annal of geophysics,vol 48.N.6, pp.937-944,December.2005

Kayode J. S., P. Nyabese and A.O. Adelusi."Ground magnetic study of llesa east, Southwestern Nigeria". *Africa Journal of Environmental Science and Technology* Vol.4(3), pp.122-131, March,2010.

Vouillamoz J.M., B, Chatenoux, F. Mathieu, J.M. Baltassalt, A. Legechenko. "Efficiency of joint use of MRS and VES to characterize coastal aquifer in Myanmar". *Journal of Applied Geophysics,* vol.61,pp.142-154.2007

John. M. Reynolds. An introduction to Applied and Environmental Geophysic. New York: John Wiley and Son Ltd, 1997,pp. 434-465

Kazmin,V." Geology of Ethiopia Explanatory notes to geological map of Ethiopia 1:2,000,000, Ethiopia" Institute of Geological survey.1979.

Menke, William.Geophysical data analysis. United Kingdom: academic press Inc. (London) ltd,1984, pp.45-55

Mohr, P.A." The geology of Ethiopia", Hailessilase I University Press, 1961,1964 and 1979.

Roel Snieder and Jeannot trampert. "Inverse problem in Geophysics". New York: ,Ed.A. Wirgin,Springer Verlag, p.119-190,1999

Sri Niwas and Olivar A.L. de Lima. "Unified equation for straightforward inversion scheme on vertical electrical sounding data". Geophysica,vol. 23 No.1,pp.22-33, April.2006.

Telford, W.M, and Others.Applied Geophysics.New York: Cambrige university press,1976,pp.72-73,524-532.

Ugwu, N.U., Ranganai, R.T., Simon, R.Egeo and Ogubazghi, G." Geo- electrical Evaluation of ground water potential and Vulnerability of Overburden Aquifer at Onibu-Eja-Active Open Dumpsite". Osogbo, southwestern *Nigeria Journal of water resource and protection,* Vol.8, pp.311-329, March, 2016.

William Lowerie. Fundamentals of Geophysics.New York: Cambridge university press, 2007, pp.252-256,293-320

Zohdy, A.A."The auxiliary point method of electrical sounding interpretation and relationto Dar zarrouk parameters". Geophysics, V.30, no.4,pp.644-660.1965.

****