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Application of Integrated 2D Total Magnetic Field Model, Electrical Resistivity Sounding Sections to Determine Geophysical Property of Over Burden Deposit and Bed Rock Beneath it a Case Study

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Abstract

One seven hundred eighty meter with ten meter spacing magnetic profile and two vertical electrical sounding using Schlumberger configuration with electrode spacing of AB/2=750m were carried out in TIta ,north east Ethiopia. The field data were smoothened and interpreted using Potent version 4.09 2 January 2007 demo mode for magnetic subsurface model,IX1D Version2.21 April 2015 and IPI2win(2008) for vertical electrical resistivity sounding inversion softwares. The 2D magnetic field model ,Geo-electrical section ,total transversal resistance ,longitudinal conductance and apparent resistivity vertical derivative transformation pseudo-section were used to determine the thickness of the over burden and characterise the bed rock. The 2D magnetic field model indicates 54m thickness of the over burden in NE part of section ,13m in the middle section and 34m in SW part of section. The magnetic susceptibility is 0.066SI along width and -0.0489SI along height. The vertical derivative transformation indicates that from highly to the slightly fracture basalt could be tilt from NE dip to ward SW which has positive correlation with 2D magnetic field model result. The true resistivity section indicates that from highly to slightly fracture basalt could have top depth -51.6m NE part and -101m SW. In addition to total transversal resistance section values have range from 2,500Ωm^2 to 5,000Ωm^2 and longitudinal conductance values are range from 11.8 Siemen to 12.8 Siemen.

Key words: Bed Rock; Magnetic Susceptibility; True Resistivity; Total Longitudinal Conductance; Total Transversal Resistance; Vertical Derivative Transformation Apparent Resistivity.

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1. Introduction

One of the basic problems in geophysical data analysis and interpretation is to get unique solution or model parameters. Interpretation of geophysical technique is not an easy task. The best approach should be understood. That is why it is attempted in this study to correlate the result of pseudo-section vertical derivative transformation to determine and control the anticipated model of subsurface with additional a prior information. Qualitative approach has a potential to give a prior information how to handle the inversion of the field data to get best model parameter. In this investigation work, instead of using only pseudo-section of apparent resistivity, pseudo-section vertical derivative transformation is being considered as means to get best image of subsurface. The total magnetic field responses and vertical electrical sounding techniques which may be applied by using the Schlumberger configuration can provide means of acquiring information about the vertical distribution of subsurface geological formation overlying the basement rock.

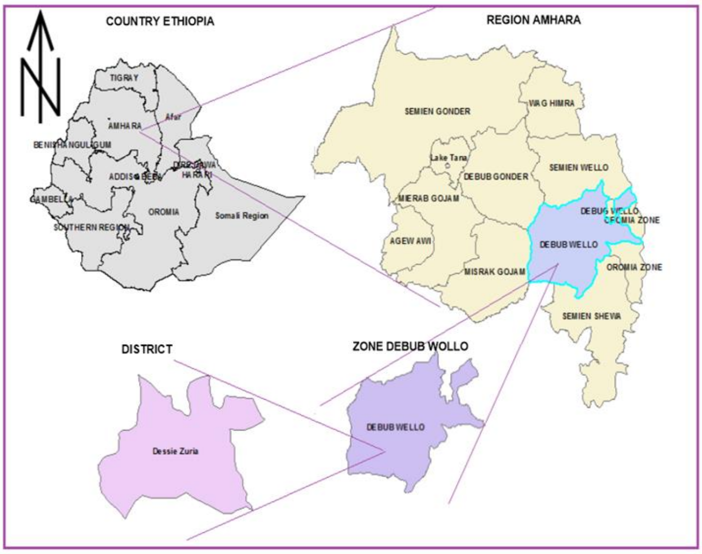


Figure 1: Location map of study area (sub region, region and country)

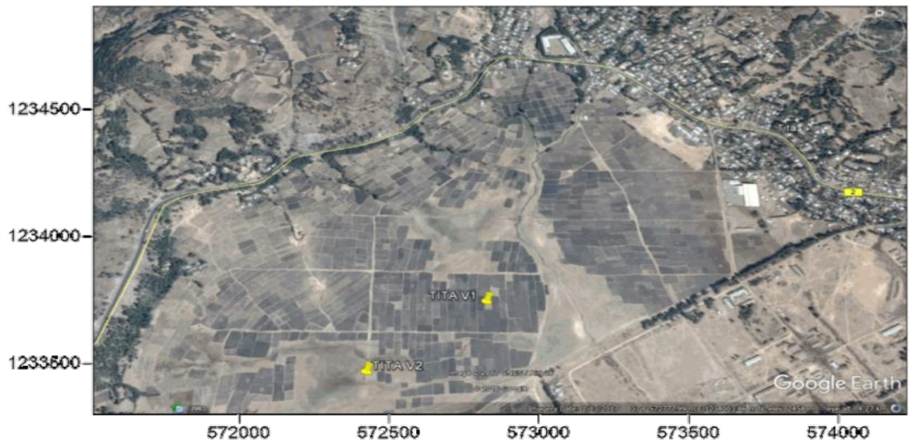


Figure 2: Google earth location map of the study area

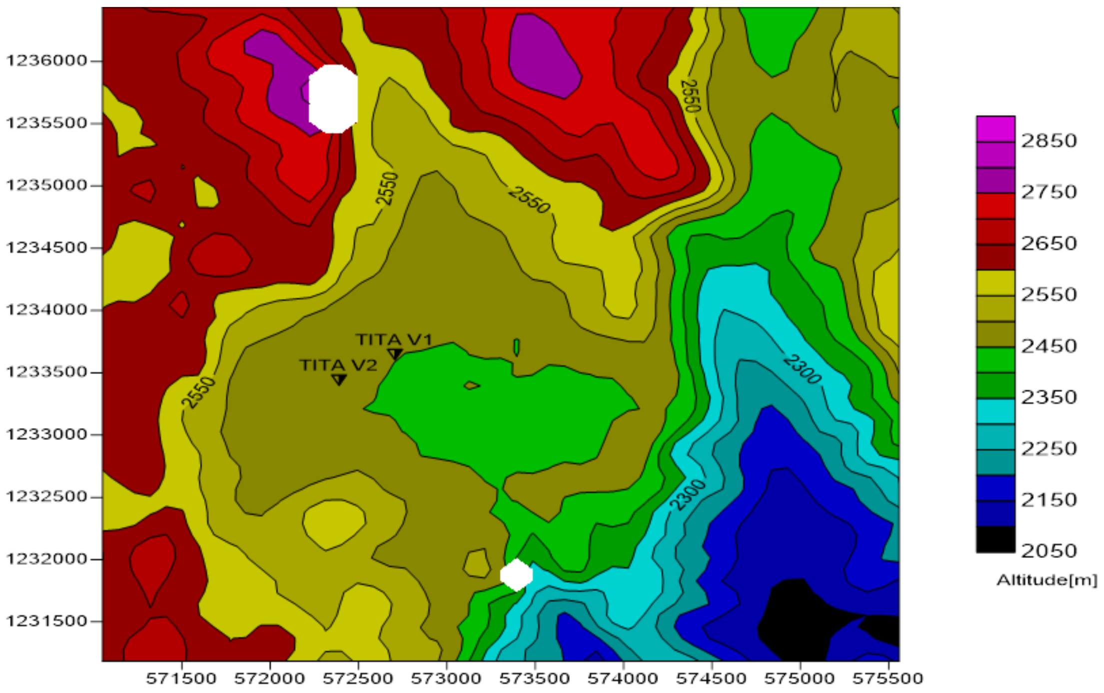


Figure 3: Contour map of the study area

2. The location and geology of the study area

2.1. Location of the study area

Tita is situated in the north eastern part of Ethiopia in the vicinity of Dessie district. It lies between [1227000, 1242000] latitude and [561000, 576000] longitude UTM coordinate system which has adindan Ethiopia datum Figure1 and 2 which can be accessed by asphalt road from Dessie to Hayk.

2.2. Regional Geology of the study area

Tita area is situated in area where high tectonic effect result revealed such as Borkena mega geological structure, from small to medium size geological structures and possible fault zone depicted in contour map figure 3.The area where the Tita area is located has flat topography and it is characterized by two formations rhyolite and basalt at the mountainous area and alluvial deposit at the low lying area. Area underlain by crystalline basement rocks occupies 40% [16] of the area of sub-Sahara Africa. Weathering activity plays significant roles in porosity and permeability of rocks. Porosity and permeability in weathered zone vary through the rock. Generally, Porosity in the rock decrease with depth. However, permeability depends on the extent of fracturing and clay contents [7, 17].

From regional geological map figure 4, ashangi formation, deeply weathered alkaline and transitional basalt flow with rare intercalation of tuff is dominated in eastern, north eastern and south eastern; Tarmaber-Mengezez formation transitional and alkaline basalt is dominated in central, western part and alajae formation from transitional and sub alkaline basalt with minor rhyolite and eruption is dominated in the south west of study area [7, 8, 17].

2.3. Rhyolite

The main geological formation that covers the study area is alagie formation mainly of rhyolite and this formation is highly fractured and moderately weathered. Outcrops at the ridge eastern and north of Tita and at the western dissected highland plateaus and ridges elongated in north-south direction. The most important exposures that were used to study the geology of the study area using the field traverses are river and road cuts and the natural exposures at different parts of the mountains surrounding the project area. As observed from the different exposures this main geological formation of the area (rhyolite) is highly fractured and slightly weathered, at some places it is highly fragmented [17].

2.3. The alluvial deposits

On the other hand the sediment at the low laying area around this project area(Tita) is found to be composed of thick deposit reaching 60m (according to the geophysical mainly VES conducted) which is characterized by different degree of gradation from silt to gravel. Apart from the geophysical survey there were also a chance to observe the thickness and sorting of this geologic material from a river channel. Mainly as can be observed from the Begkendi River the alluvial deposit gradation ranges from clay to, pebbles, sand and other more alluvial deposit types [17].

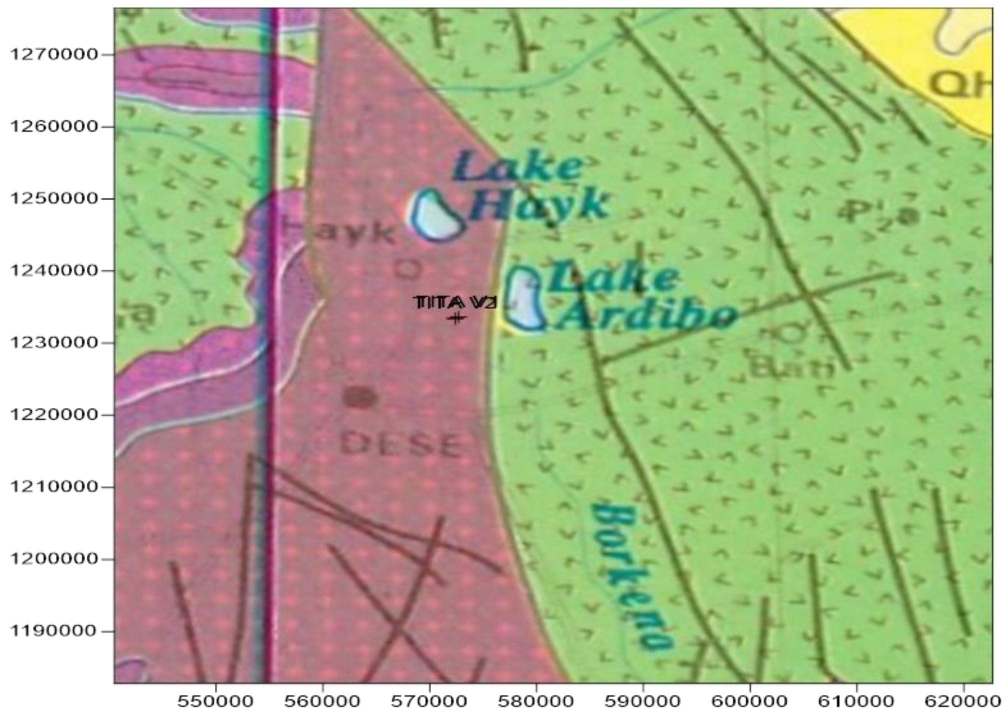
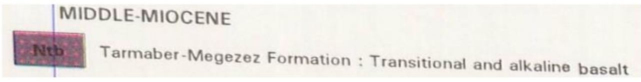
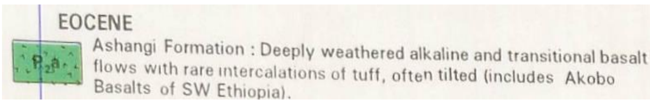


Figure 4: Geo-referenced geological map of the study area [18]

Legend

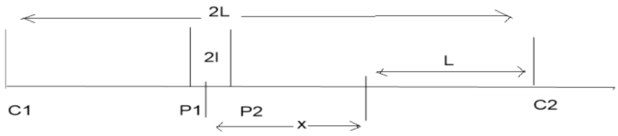




3. Materials and methods

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 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 [14]. 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

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

$$\rho_1 \left[1 + 2D_s'\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$ [9].

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

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

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 [4].

4. 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 Tita is calculated, which is equal to

F=36367nT, **D**=2.36^{o} East and **I**= 7.95^{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 two different points selected from magnetic profiling.Titav1 is conducted at high magnetic response 36540.7nT at a point 600m and at low magnetic response Titav2 36410.3nT 250m at a point from initial position.

5. 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 wares 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.

5.1. Qualitative data analysis and interpretation

5.1.1. 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 [572859, 1233748, 2446] to [572017, 1233249, 2470] which has a length of 780m with 10m spacing. The data is plotted in the figure 5 indicates that two different response at [20m, 650m] has high response and [200m, 400m] has low response. Even though interpretation by magnetic method is the most complex geophysical method [15]. It is possible to retrieve information from graph that along a given profile, polygonal prism model can be generated. From the magnetic profile two different peaks values are selected to conduct and distinct catchment based on the result of geophysical resistivity responses that two vertical electrical sounding Tita V1 and TitaV2 Schlumberger configuration conducted. Having different magnetic response on this profile, the vertical electrical resistivity sounding (VES) station could be easily identified. So that upper peak I for Tita V1 and lower peak II for Tita V2. 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 surface stream, at point 'B' and 'D' very shallow thin dike structure.

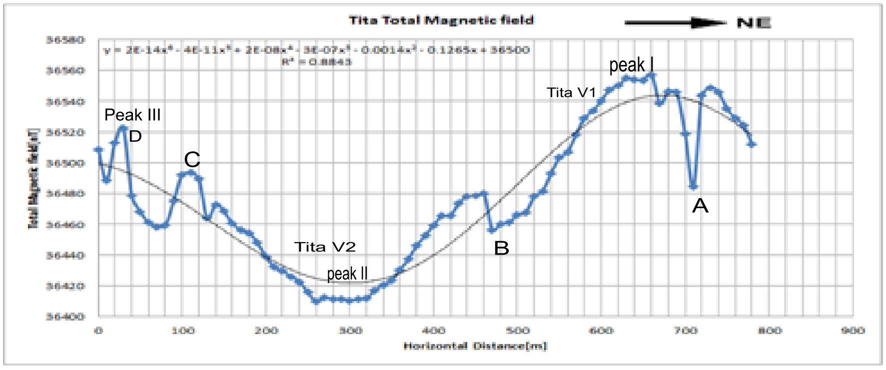


Figure 5: Measured magnetic field data graph

5.1.2. Pseudo geo-electrical section

Based on the result from magnetic profiling, vertical electrical resistivity soundings (VES) TITAV1 and TITAV2 had been conducted. Pseudo-section of the VES data was plotted as shown in figure 6. Pseudo-section indicates that the apparent resistivity values increased with depth in both NE and SW 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≥ 316m. In addition high apparent response could be response of basement rocks.

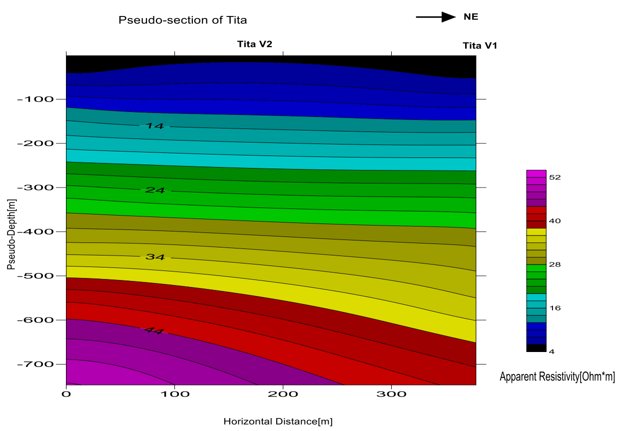


Figure 6: Geo-electrical pseudo-section of the study area

5.2. 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 [13]. The polynomial best fit for

TITAV1

$$\rho_a = 7E - 15s^6 + 1E - 11s^5 + 1E - 08s^4 + 4E - 06s^3 + 0.0009s^2 - 0.0135s + 4.7101 \ldots\ldots(4)$$

TITAV2

$$\rho_a = 9E - 15s^6 - 2E - 11s^5 + 2E - 08s^4 - 7E - 06s^3 + 0.0012s^2 - 0.0055s^1 + 5.1358 \ldots.(5)$$

$$V.d.t = \frac{\partial \rho_a}{\partial s} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

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 7. So that understanding pseudo-section vertical transformation can help interpreter to handle both geo-electrical section shown in figure 8 and magnetic model shown in figure 9. 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 equivalence problem. But if the vertical derivative transformation is computed, it could provide likihood values of the bed rock.

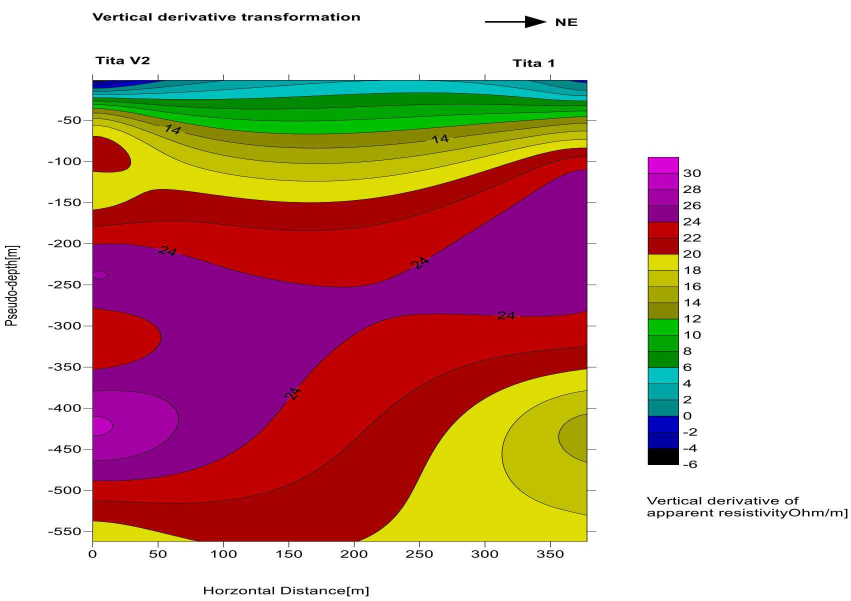


Figure 7: Pseudo-section of vertical derivative transformation

5.3. Quantitative data analysis and interpretation

TITAV1 and TITAV2 VES 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 TITAV1 and TITAV2 are inverted to get model parameters that could define subsurface of the earth. To get the best fit curve and model 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 problem in three model inversion approaches.

5.3.1. Equivalence

There are two types of equivalence problems in electrical resistivity techniques

5.3.1.1. 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 [1]. The ratio of

$$S = h/\rho = constant \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

5.3.1.2. 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 [1, 9]. The product of $T = h\rho = constant \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$

5.3.2. Suppression

This occurs when the curve type is either A-type or Q-type. Thin layer effect should be considered in interpretation process [1, 9].

5.3.5. 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 [2] $R = G^{-g}G$; R-Resolution matrix-g-Generalized inverse data kernel and G-Data kernel

Figure 14 and Figure 15 show that the 1D interpreted resistivity model, TITAV1 has K type three layers and

TITAV2 has A type three layers.

5.4. Geophysical data inversion

5.4.1. 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

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

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 [2].

TITAV1 has the following parameter bound.

Table 1: Equivalence Analysis

Type	Layer	Minimum	Best	Maximum
RHO	1	4.56	4.69	4.81
	2	25.33	384.92	1781.76
	3	64.76	81.91	108.12
THICK	1	48.01	51.62	55.18
	2	1.32	10.65	49.29

Table 2: Parametric Resolution Matrix

RHO1	1.00				
RHO2	0.00	0.01			
RHO3	0.00	0.06	0.83		
RHO1	0.00	-0.03	-0.03	0.99	
RHO2	0.00	0.01	0.05	-0.02	0.01
	R1	R2	R3	T1	T2

TITAV2 has the following parameter bound.

Table 3: Equivalence Analysis

Type	Layer	Minimum	Best	Maximum
Rho	1	4.46	4.61	4.76
	2	11.69	19.62	34.88
	3	129.37	208.47	450.18
Thick	1	24.49	29.02	34.85
	2	56.00	101.70	197.32

Table 4: Parametric Resolution Matrix

RHO1	1.00				
RHO2	0.00	0.56			
RHO3	0.00	-0.05	0.38		
RHO1	0.00	-0.17	0.00	0.91	
RHO2	0.00	-0.27	-0.24	-0.07	0.69
	R1	R2	R3	T1	T2

5.4.2. Geo-electrical section Representation and Interpretation

Geo-electrical section indicates in figure 9 that three layers are identified in both NE and SW parts. The first NE part section has best estimated averaged thickness 51.62m and true resistivity 4.69Ωm which could the response of alluvial deposited and/or highly decomposed and weathered basalt (rhyolite) saturated with water [14]. The second layer is relatively thin and high resistive layer which has 10.65m and true resistivity 384.92Ωm from Table1.The first SW part of the section has 29.02m and true resistivity 4.61Ωm which could be the response of alluvial deposited and/or highly decomposed basalt (rhyolite) saturated with water. The second layer is relatively thick and low resistive layer which has 101.70m and the true resistivity 19.62Ωm from the table3.The resolution matrix in table2 indicates that the third layer resistivity of TITAV1 is 0.83and the resolution matrix from table4 indicates that the third layer resistivity of TITAV2 is 0.38 which can confirm that TITAV1 third layer may be estimated better than TITAV2.From vertical derivative transformation, the last layer could be low resistivity for TITAV1 but it could continue high resistive TITAV2.But the third layer resistivity value for TITAV2 208.4 could be response of from highly fracture to moderately fracture basalt(rhyolite) which is relatively high resistive layer in subsurface. The resolution matrix 0.38 and equivalence analysis of resistivity [129.37, 450.18] of TITAV2 describe the resistivity values are not well resolved and the range of resistivity value could not be clearly identified as highly fracture or moderately but the probability being massive rock is low.

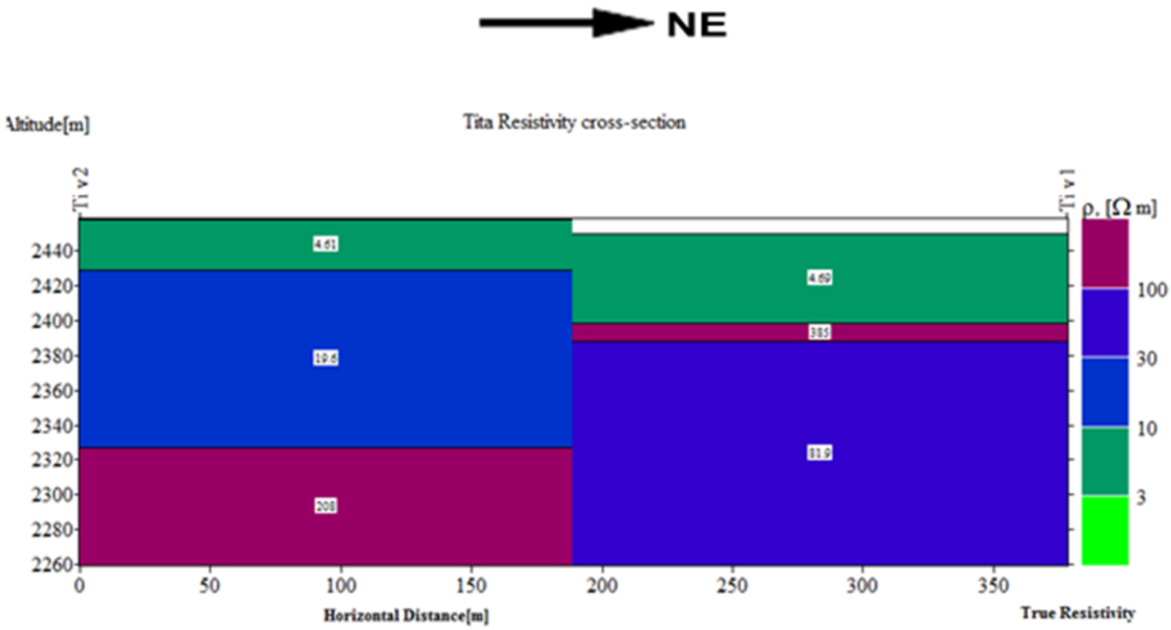


Figure 8: Geo-electrical sections of TITA V1 and TITA V2

[ρ,h] is the order of parameters in figure 8

5.4.3. 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 is between station 200m and station 700m.The depth of magnetic model section has a range between 13m and 54m. The vertex of section has depth of 34m as shown in figure 9.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) $\chi_A = 0.0666SI$ 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) $\chi_C = -0.0489SI$ which could be the response of decomposed,highly weather basalt. Which could be magnetized by $F\sin I$ prevailing geomagnetic field and attribute no significant maagnetization.When volcanic rock decomposed its microscopic magnetization(M) could be arranged randomly and cause the inducing magnetic field to reduce its magnitude strength when vector addition of Magnetic induction vectors execute. Since magnetic susceptibility $\chi = \frac{\Delta B}{B_o}$ becomes negative where B_o is the inducing magnetic field [1,9].

The magnetic model section of tita study area could have three layers.The first layer has the thickness ranges from 13m to 54m.SW part section could have clay,clayey sand.The second layer could have thickness of

41m. 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.

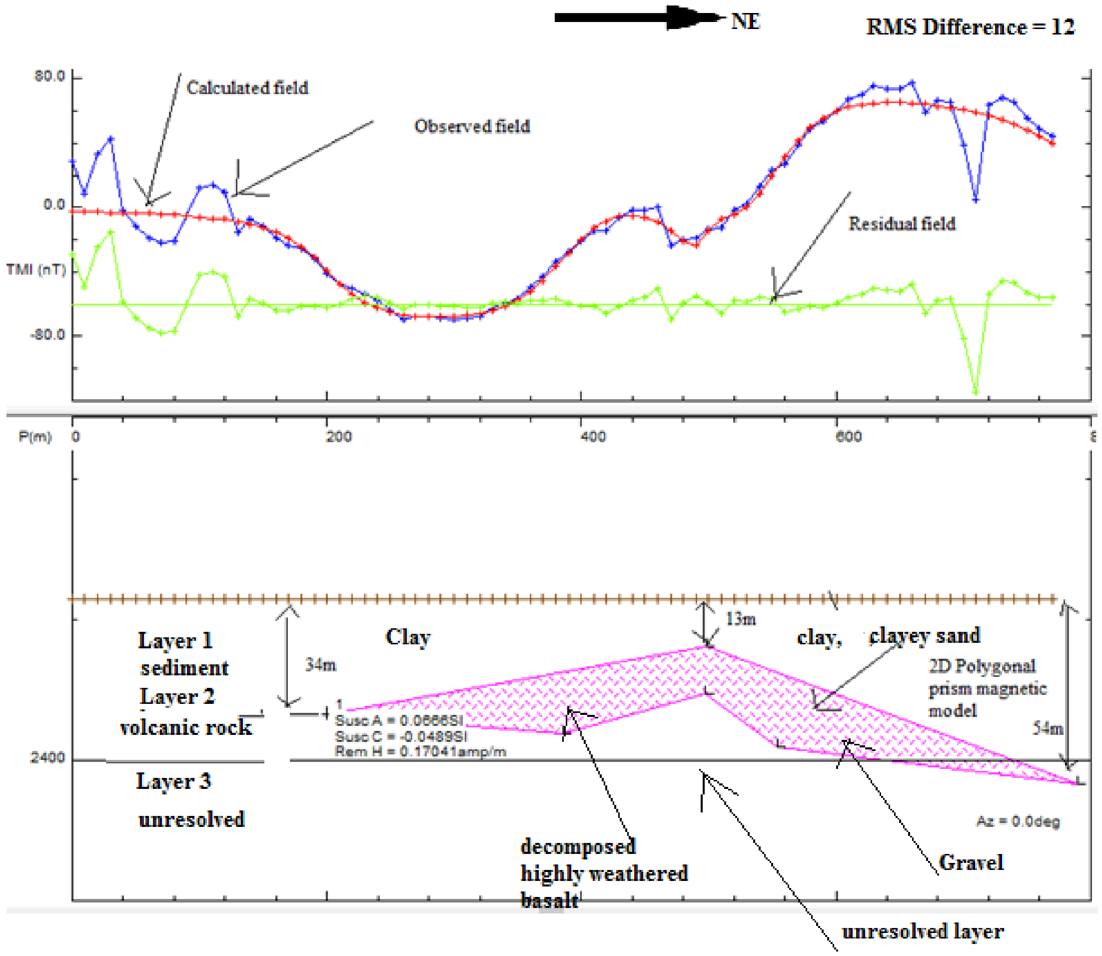


Figure 9: 2D Magnetic Field model of the study area

5.4.4. Darzarouk function and Variable Representation and Interpretation

5.4.4.1. Transversal resistance

Transversal resistance of NE part of section is 400Ωm^2 which could be response of moderate/slightly fractured basalt at 62.27m depth and Transversal resistance of SW part of section is 2,500Ωm^2 which could be the response of moderate/slightly agglomerate fractured basalt at depth 130.72m. This indicates that that pure basalt could have higher transversal resistance than slightly agglomerated basalt.

5.4.4.2. Longitudinal conductance

Longitudinal conductance at NE part section is 12.8 Siemen and thickness of the clay is 30m whereas SW part of section is 11.8 Siemen and thickness of clay is 20m.This 1 Siemen difference could be correlated with 10m thickness change. 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.

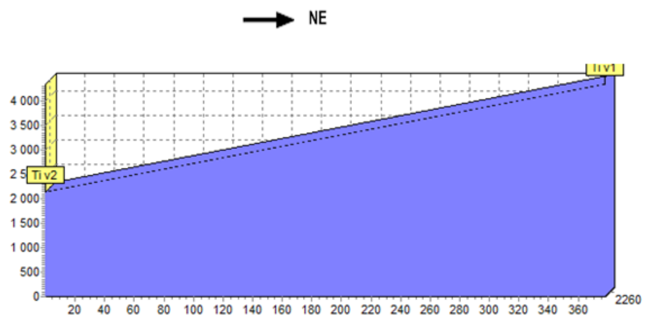


Figure 10: Transversal Resistances of TITAV1 and TITAV2

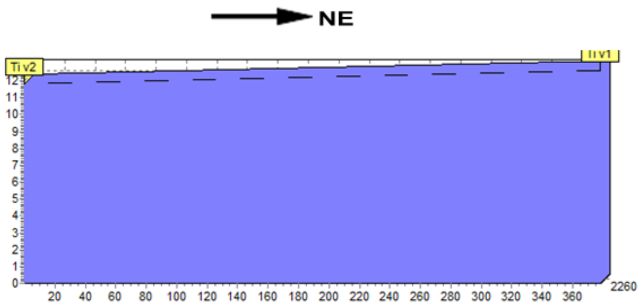


Figure 11: Longitudinal conductances of TITAV1 and TITAV2

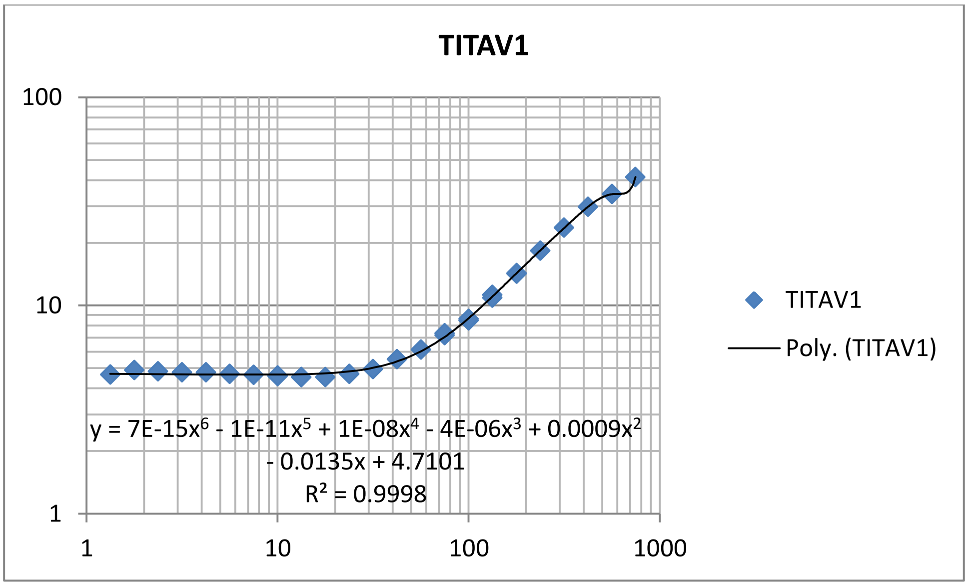


Figure 12: Raw data graph of TITAV1 on logarithmic sheet

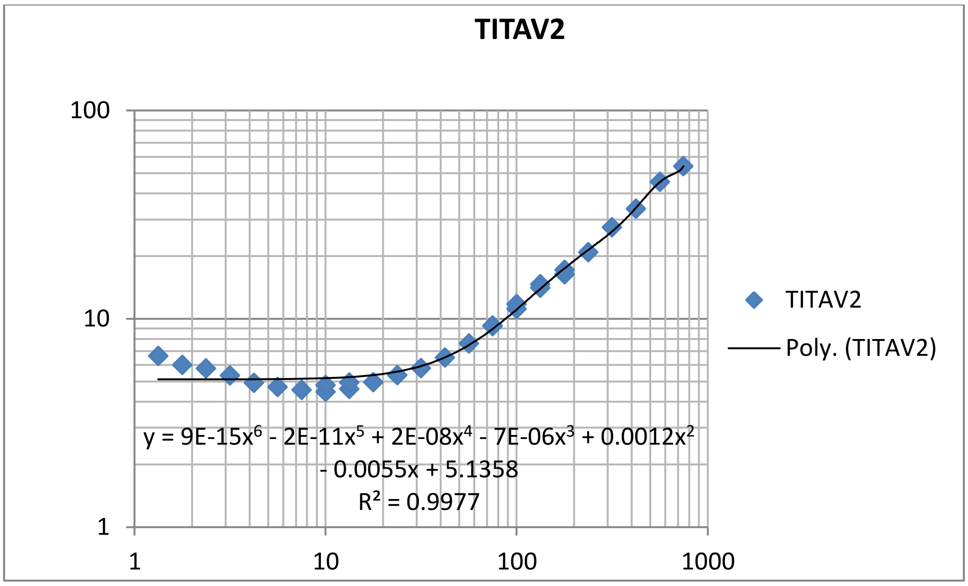
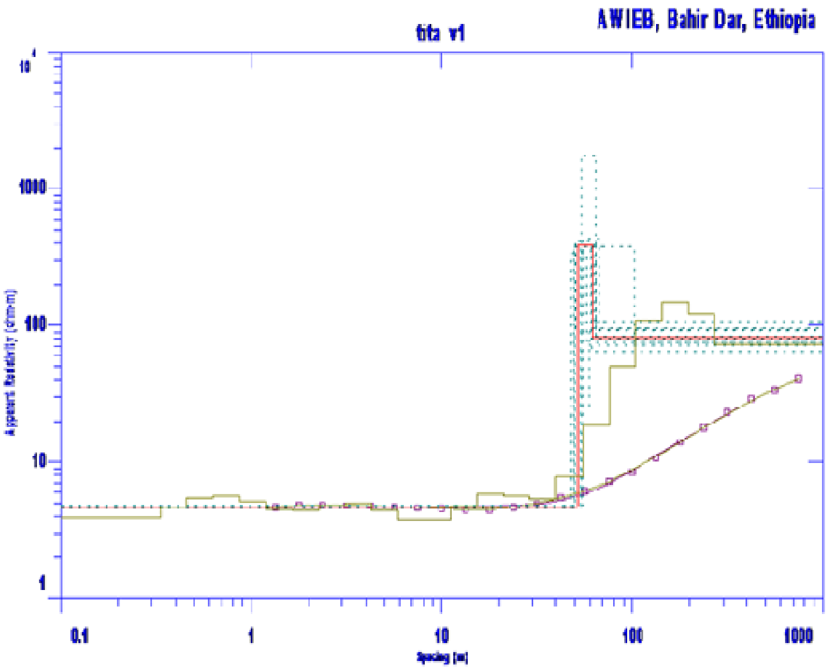
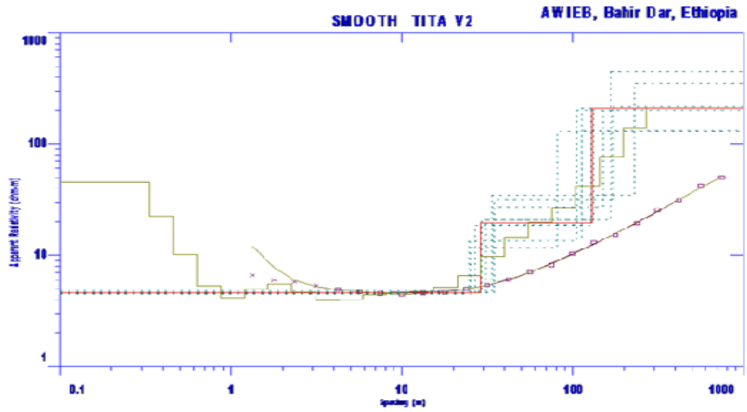


Figure 13: Raw data graph of TITAV2 on logarithmic sheet



DATASET:	tita	v1	NORTH:	1233441	EAST:	572706	ELEVATION:	2450
LAYER	RESISTIVITY	THICKNESS	DEPTH	ELEVATION	LONG.	COND.	T.	RESIST.
1	4.7	51.6	51.6	2398.4	11		242	
2	384.9	10.6	62.3	2387.7	0		4098.3	
3	81.9							

Figure 14: Data inversion model of TITA V1



DATASET:	SMOOTH	TITA	V2	NORTH:	1233441	EAST:	572389	ELEVATION:	2458
LAYER	RESISTIVITY	THICKNESS	DEPTH	ELEVATION	LONG.	COND.	T.	RESIST.	
1	4.6	29	29	2429	6.3	133.8	133.8		
2	19.6	101.7	130.7	2327.3	5.2	1995.8	1995.8		
3	208.5								

Figure 15: Data inversion model of TITAV2

6. Conclusion

NE part of 2D total magnetic field model section and TITAV1 model indicates that overburden deposit thickness are 54m and 51.6m respectively and also SW part of magnetic model section and TITAV2 indicate that the over burden thickness are 34m and 29m respectively. Those results show that both methods can resolve the over deposit with difference 2.4m in NE and 5m in SW. The magnetic susceptibility values along NE strike is 0.066SI which could be response of fractured basalt and -0.0489SI which could be the response of slightly fractured agglomerate basalt (Quartz fill).

The maximum top pseudo depth values of V.T.D. are approximately 140m and 200m at Tita V1 and Tita V2 respectively, this shows that it could be possible to estimate the maximum likihood depth of bed rock and its pattern of geo-electrical section.

The longitudinal conductance and its thickness values are 12.8 Siemen and 30m in NE and 11.8siemen and 20m in SW this indicates that the protective capacity NE part of section is higher than SW.

7. Limitations of the study

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

8. 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.

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 problem and suppression. 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.

9. Well drilling result of the study area

Table 5: Tita V1 station lithological description

Drilled Depth (m)		***Lithological Description***	***Thickness***	***Type of formation***	***Remark***
From	***To***				
0	*30*	*Clay*	*30*	*Soft*	
30	*44*	*Clay with sand*	*14*	*Soft*	
44	*50*	*Gravel*	*6*	*Soft*	
50	*72*	*Sand with Gravel*	*22*	*Soft*	
72	*80*	*Slightly fractured basalt*	*8*	*Hard*	
80	*107*	*Moderately fractured basalt*	*27*	*Hard*	
107	*111*	*Slightly fractured basalt*	*4*	*Hard*	
111	*171*	*Highly weathered basalt*	*60*	*Medium*	
171	*183*	*Moderately fractured and weathered basalt*	*12*	*Hard*	
183	*191*	*Slightly fractured basalt*	*8*	*Hard*	
191	*195*	*Massive basalt*	*4*	*Hard*	

Table 6: Tita V2 station lithological description

Drilled Depth (m)		***Lithological Description***	***Thickness***	***Type of formation***	***Remark***
From	***To***				
0	*20*	*Clay*	*20*	*Soft*	
20	*52*	*Decomposed(highly weathered) basalt*	*32*	*Soft*	
52	*60*	*Moderately fracture agglomerate basalt*	*8*	*Medium*	
60	*66*	*Highly fractural basalt*	*6*	*Soft*	
66	*80*	*slightly fracture agglomerate basalt(Quartz fill)*	*14*	*Hard*	
80	*92*	*Massive basalt*	*12*	*Hard*	
92	*94*	*Slightly fractured basalt*	*2*	*Hard*	
94	*110*	*Highly fracture basalt*	*16*	*Soft*	
110	*116*	*Slightly Fractured basalt*	*6*	*Hard*	
116	*124*	*Highly fractured basalt*	*8*	*Soft*	
124	*126*	*Iron rich(slightly fractural basalt)*	*2*	*Hard*	
126	*130*	*Highly fractural basalt*	*4*	*Soft*	
130	*132*	*Slightly fractural basalt*	*2*	*Hard*	
132	*140*	*Highly fractural basalt*	*8*	*Soft*	
140	*146*	*Slightly fractural basalt*	*6*	*Hard*	
146	*148*	*Decomposed basalt*	*2*	*Soft*	
148	*156*	*Moderately fracture agglomerate basalt*	*8*	*medium*	
156	*166*	*Highly fractural basalt*	*10*	*Soft*	
166	*174*	*Slightly fractural basalt*	*8*	*Hard*	
174	*180*	*Massive basalt*	*6*	*Hard*	

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Reference

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

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

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

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

[5]. 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.

[6]. 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.

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

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

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

[10]. Geological Surveys of Ethiopia. "Geology of Ethiopia".1999.

[11]. 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

[12]. 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.

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

[14]. J.M. Vouillamoz, 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

[15]. J. S. Kayode, 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.

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

[17]. 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

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