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Groundwater Exploration of Federal College of Education (Technical) Akoka Lagos Nigeria Community Using Schlumberger Array

Ajayi Ayotunde Abel[1], Bakre Omolara Fatimah[2*], and Babatunde Peter[3]

[1]Department of Physics Education, Federal College of Education (Technical), Akoka, Lagos
[2]Department of Mathematics/Statistics, Federal College of Education (Technical), Akoka, Lagos
[3]Department of Physics Education, Federal College of Education (Technical), Akoka, Lagos

E-mail: ajayi.ayotunde@fcet-akoka.edu.ng; bakre.omolara@fcet-akoka.edu.ng; babatunde.peter@fcet-akoka.edu.ng

*Corresponding author details: Bakre Omolara Fatimah; bakre.omolara@fcet-akoka.edu.ng

ABSTRACT

A total of thirteen (13) Vertical Electrical Soundings (VES) using Schlumberger array were carried out within Federal College of Education (Tech) Akoka, Yaba, Lagos State, Southwestern, Nigeria. This area is between Longitude N06º31'10" and Longitude N06º31'30" and Latitude E3º22' 55" and Latitude E3º23' 5.3". This study was necessary because of the roles water plays in human life, the demand for it and the failure of boreholes in some locations within the study area. Resistivity method of geophysical survey was applied to determine good locations for groundwater prospecting using PASI Terrameter and its accessories. The resistivity values obtained were plotted on a log-log graph scale for curve matching and computer iteration was carried out using WinResist software to generate computer models for the curve types. The Geoelectric sections beneath each VES point revealed about four to five geoelectric layers, comprising topsoil, sandy-clay, clayey-sand, clay, peat, and sandy formation. Analysis of geophysical investigation showed that sand at the third geoelectric layer in VES 1 and VES 11 with a resistivity value of 143.3 Ωm and 240 Ωm constitute aquifer units where groundwater can be tapped. The shallow groundwater could be tapped at depth interval 6.6-20.2 m in VES 1 and 25.2m and above in VES 11. The failure of borehole located within the female hostel was due to overburden of this shallow aquifer due to population explosion. The recommendation was made that groundwater development through borehole drilling of depth not less than 150m is needed for high groundwater yield based on available information from nearby well log since wider spread for the deep investigation is not possible within the study area.

Keywords: vertical electrical sounding; resistivity; geo-electric layers; groundwater

INTRODUCTION

Federal College of Education (Technical) Akoka is one of the tertiary institutions in Lagos state, South-western Nigeria (figure 1). A total of thirteen (13) Vertical Electrical Soundings (VES) using Schlumberger array were carried out within the study area. The population of the inhabitants of this community put pressure on existing water sources and hence, the need to explore more locations where groundwater can be made available for the ever-growing population. Vertical Electrical Sounding of resistivity survey method was employed to determine the subsurface layers of the ground within the study area with a view to provide necessary information on the subsurface strata of the ground because of resistivity variations with respect to depths and lithology towards groundwater mapping and determination of vulnerability of aquifers and shallow aquifers.

Geoelectric characterization of subsurface layers includes mapping the depth and thickness of each layer, mapping aquifers, locating preferential fluid migration path such as fractures and fault zones and mapping contaminants to the groundwater (Fatoba and Olorunfemi, 2004). Subsurface characterization can also reveal the presence of cavity beneath the ground, buried pipelines, and variation in the thickness of topsoil which may serve as a basis for soil erosion and earth movement detection.

Generally, the electrical resistivity method of geophysical survey employs an artificial source of current which is introduced into the ground through point electrodes or long line contacts (Telford, Geldart and Sheriff, 1990). Vertical Electrical Sounding of resistivity method has been successfully used to study horizontal and vertical discontinuities in the electrical properties of the ground, since different rocks (lithologies) respond differently to current, based on some properties, such as, fluid saturation, fluid concentration, porosity, permeability, temperature, age of the rock, and mineral compositions etc.

Subsurface resistivity surveying is based on the principle that the distribution of electrical potential in the ground around a current carrying electrode depends on resistivity distribution of the surrounding soils and rocks. It is a versatile geophysical tool in hydrogeology, besides its application in mineral exploration, engineering, environmental Geophysics and in delineating lithofacies.

This method was described by Ezomo and Ifedili (2006), Oyedele (2008) and Ezomo (2012) as simple, most widely used, very efficient and cost effective. Also, an excellent example of the use of this technique was shown by Reynold (1997) in a survey for a rural water supply in Northern Nigeria where the failure rate of boreholes sank at that time was over 82% before the Vertical Electrical Soundings were used.

Schlumbeger electrode array has been successfully used by many researchers. Badmus and Ayolabi, (2005) delineate limestone of Ewekoro formation using this method. Atakpo and Akpoborie, (2011) recognised the successful application of electrical resistivity method for many geological and groundwater investigations in the Niger Delta. Adepelumi, Olorunfemi, Falebita and Bayowa (2008), carried out VES survey utilizing surface Schlumberger electrode spacing varying between 1m and 50m to delineate saltwater intrusion into freshwater aquifer of Lekki Pennisula in Lagos State. The resistivity result reveals a dominant trend of decreasing resistivity with depth which indicates increasing salinity with depth.

The vulnerability of aquifers is closely related to the heterogeneity of the clay cap. The clay content of the formation defines the electrical resistivity with clayish less permeable formations showing low resistivity and sandy permeable formations showing high resistivity.

LOCATION AND GEOLOGY OF THE STUDY AREA

The study area is located at Federal College of Education (Technical) Akoka, Yaba, Lagos State, Southwestern, Nigeria. This area is between Longitude N06º31'10" and N06º31'30" and Latitude E3º22' 18" and Latitude E3º23' 5.3". The study area is a sedimentary terrain underlain by the Nigerian arm of the Dahomey Basin (Fig 2). The Dahomey Basin is one of the passive margin basins of the West African Atlantic coast. Its origin is closely related to the rifting and separation of the African and South American plates during the Late Jurassic and Early Cretaceous (Adegoke 1977; Omatsola & Adegoke 1981; Elvsborg & Dalode 1985). The basin is characteristically long (total length of about 800km), narrow and parallel to the coastline. It stretches from south-eastern Ghana through Togo and Benin Republics to the western margin of the Niger Delta. The basin is of high economic value as it is greatly endowed with mineral of high commercial quantities such as Bitumen, tar sand and industrial rocks and minerals such as Limestone and clay deposits (Omatsola and Adegoke 1981).

METHODOLOGY

Data acquisition and Analysis

Thirteen (13) Vertical Electrical Sounding using Schlumberger Array were carried out within the study area (Figure 1) which covers the back of School of Technical Education, Nursing Education building area, side of Centre for Educational Technology building and front of Kabir Aliyu lecture theatre building, beside independent hall, back of physics laboratory, School of Science Education, and front of Tennis Court. The PASI Terrameter and its accessories were used for field data collection. The resistivity values obtained were plotted against half of current electrode separation on log-log graph scale. The preliminary interpretation involved curve matching through which rough estimate of resistivities and thicknesses of various geoelectric layers (Tables 1&2) were obtained and final quantitative interpretation was carried out using computer iteration with WinResist software. The results obtained were used to generate curve types in the computer modelling of VES stations (VES 1-13) which are presented in Figure 9 and AutoCAD software was used to generate Geoelectric sections beneath each VES station (Figures 3-8).

RESULTS AND DISCUSSION

The quantitative interpretation of results is presented in Tables 1 and 2 while the geoelectric sections beneath the VES points are shown in Figures 3-8. Table 1. Interpreted VES results.

The results of VES data analysed showed the thickness and depth of various geoelectric layers. The Table 1 and 2, and figures (3-8) revealed the lithology, thickness, and depth of various geoelectric layers beneath VES points with topsoil having resistivity values ranging from 7.8Ωm to 231.3Ωm and thickness between 0.6m to 1.0m. The second geoelectric layer delineated as clayey formation in all geoelectric sections beneath VES points except VES 1 where it occurred in the fourth layer and occurred in the second times in the fourth layer of VES 2, VES 5, VES 6, and VES 8. Clay was also found in third layer in VES 9 and its resistivity values ranges from 1.2Ωm to 63Ωm and thickness between 1.4m to 13.8m. Sandy-clay formation occurred only in VES 1 with resistivity of 63.1Ωm and thickness 5.7m. Clayey-sand has resistivity values between 36.6Ωm to 92.8Ωm and its thickness ranges from 5.7m to 16.4m. It occurred mostly within third and fourth geoelectric layers in all VES points except VES 1, VES 10 and VES 13. Sandy formation occurred in VES 1, VES 10, VES 11 and VES 13 with resistivity values ranging from 113Ωm to 168Ωm and thickness between 13.6m to 16.1m though in VES 10 and VES 11, the thickness cannot be determined due to current termination within the zone. However, VES 3, VES 4 and VES 5 were characterised with peat at the third layer except in VES 3 where it was found in both third and fifth geoelectric layers. It has resistivity range of 3.5Ωm; between 8.9Ωm to 5.4Ωm and its thickness was between 4.3m and 14.8m though the one at fifth layer in VES 3 cannot be determined due to current termination. The sandy formation at the third layer in VES 1 and fourth layer in VES 11 represent good aquifer units where deep well or bore-hole can be sunk though this shallow groundwater could be tapped at depth between 6.6-20.2m. Also, the fourth geoelectric layer delineated in VES 11 has resistivity value of 240Ωm and composed mainly of sandy material representing a good aquifer unit too though the thickness could not be determined due to current termination at this zone.

CONCLUSION AND RECOMMENDATION

Electrical resistivity method of geophysical surveying was carried out within Federal College of Education (Tech) Akoka, Yaba, Lagos State to characterise the underlying formations for groundwater potential. Thirteen (13) Vertical Electrical Soundings through Schlumberger array were acquired within the study area. VES results revealed that the subsurface layers delineated correspond to sand, clay / peat, clayey sand, sandy-clay, and sand.

The qualitative interpretation of the VES revealed five QH, two HK, one KH and one QHK curves. These curves are diagnostic of lithologic units of the subsurface information. Analysis of the geophysical investigation showed that sand at the third geoelectric layer in VES 1 and VES 11 with a resistivity value of 143.3 Ωm and 240 Ωm constitute aquifer units where groundwater can be tapped. The shallow groundwater could be tapped at depth interval 6.6-20.2 m in VES 1 and 25.2m and above in VES 11. The over abstraction of this shallow aquifer due to population might have caused the collapse of borehole sited at the female Hostel near tennis court. However, based on the analysis of nearby well log which showed similar trend with the geology of the present area investigated, we therefore recommend groundwater development via borehole drilling of depth not less than 150 m for high groundwater yield if wider spread for the deep investigation within the study is not feasible.

APPENDIX

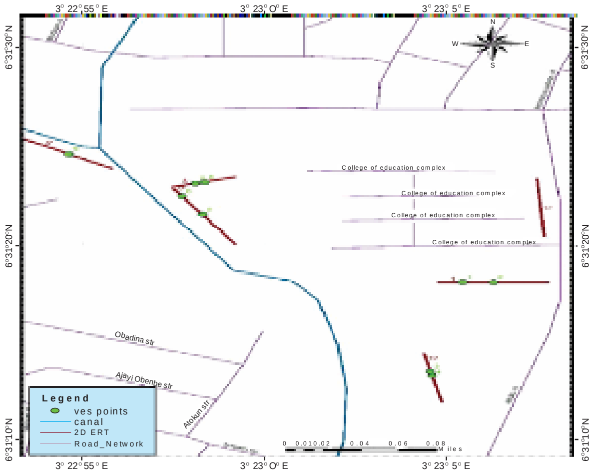

FIGURE 1: Base map of the study area.

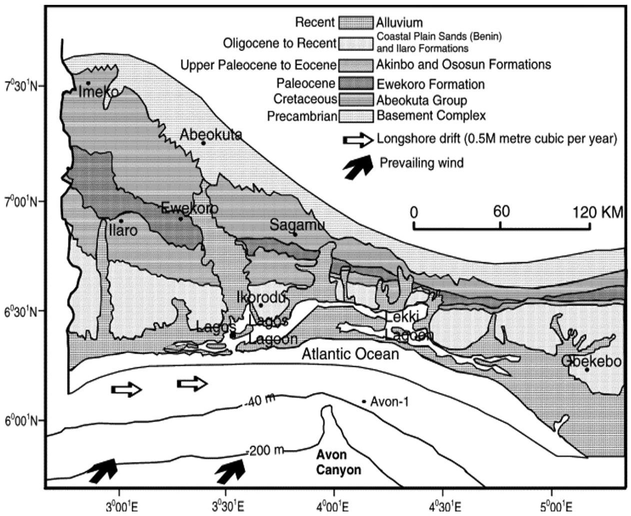

FIGURE 2: Geological Map of Lagos.

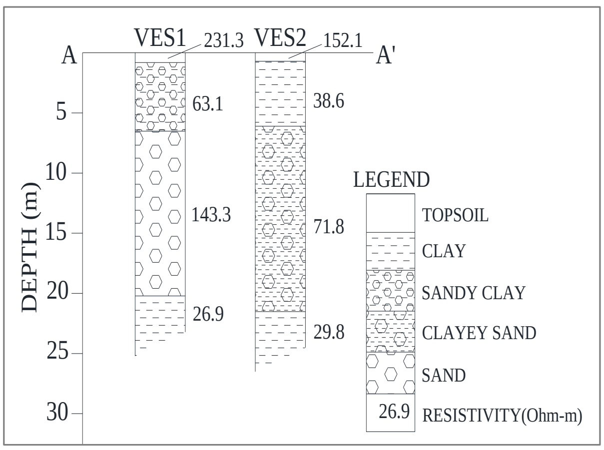

FIGURE 3: Geoelectric Section Along Female Student Hostel Near Sport Centre.

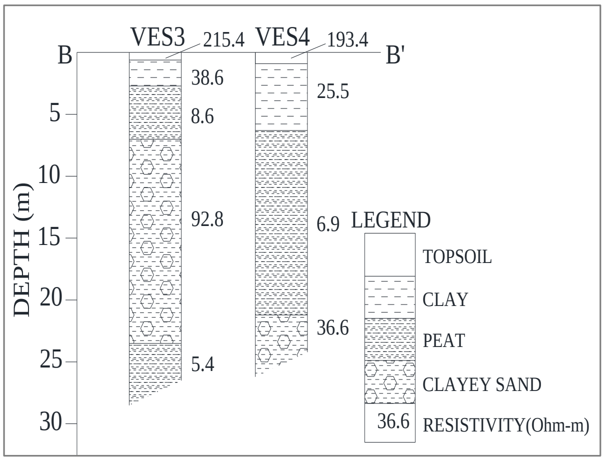

FIGURE 4: Geoelectric Section Along Nursing Education Hostel.

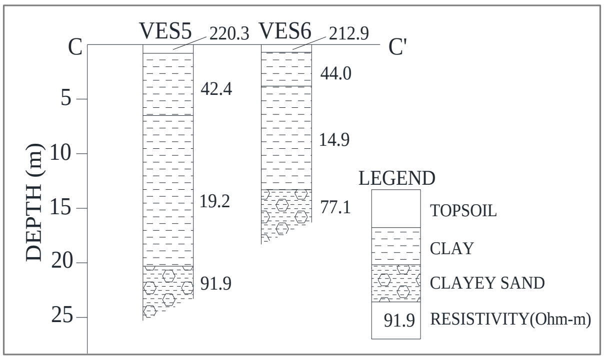

FIGURE 5: Geoelectric section along on-going Chapel Construction opposite Centre for Educational Technology.

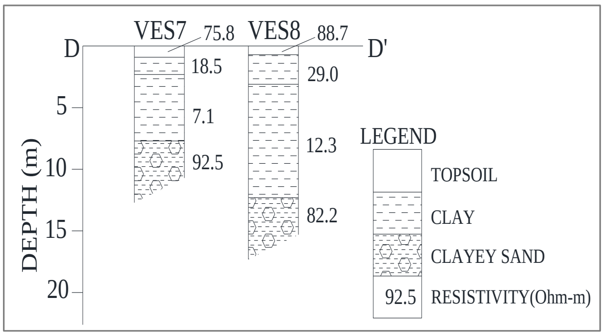

FIGURE 6: Geoelectric section along Centre for Educational Technology.

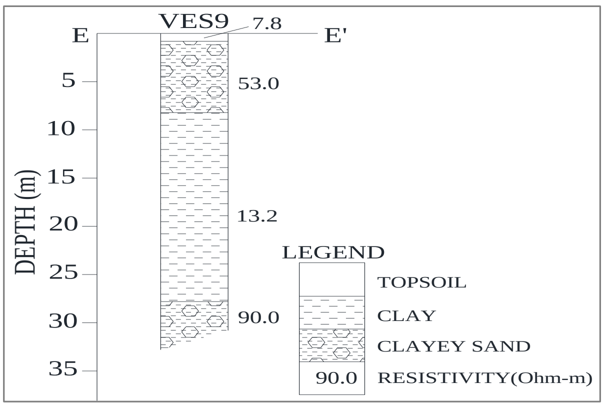

FIGURE 7: Geoelectric Section Along Kabiru Aliyu Lecture Theatre.

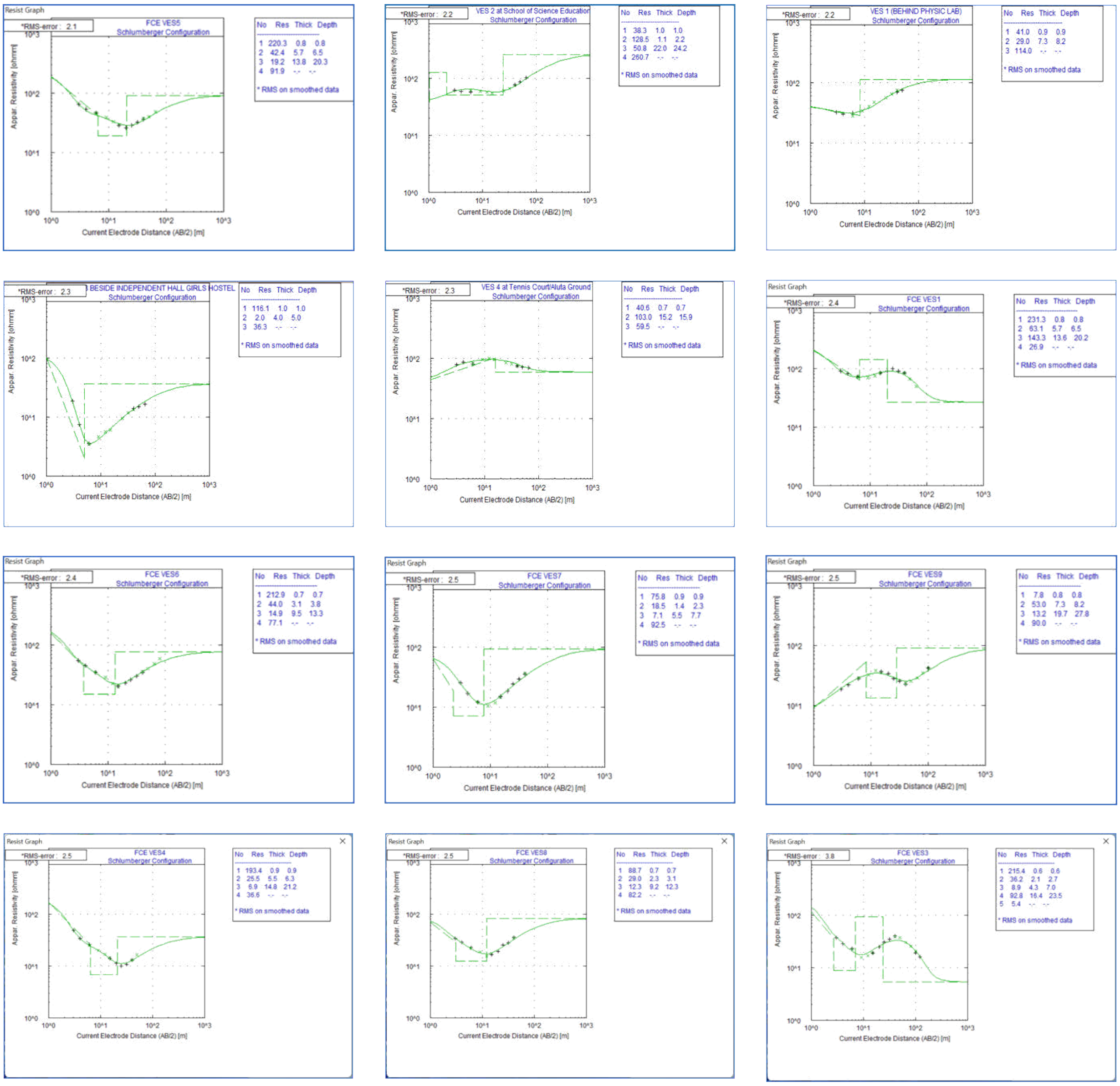

FIGURE 8: Computer iteration Models for VES points.

TABLE 1: Resistivity Values, Lithology, thickness and depth at various VES points.

VES No.	LAYERS		THICKNESS (m)	DEPTH (m)	CURVE TYPE	LITHOLOGY
1	1		0.8	0.8	**HK**	Topsoil
	2		5.7	6.5		Sandy Clay
	3	143.3	13.6	20.2	$\rho_1 > \rho_2 < \rho_3 >$	Sand
	4	26.9	---	---	ρ_4	Clay
2	1	152.1	0.7	0.7	**HK**	Topsoil
	2	38.6	5.4	6.1		Clay
	3	71.8	15.4	21.5	$\rho_1 > \rho_2 < \rho_3 >$	Clayey Sand
	4	29.8	---	---	ρ_4	Clay
3	1	215.4	0.6	0.6		Topsoil
	2	36.2	2.1	2.7	**QHK**	Clay
	3	8.9	4.3	7.0		Peat
	4	92.8	16.4	23.5	$\rho_1 > \rho_2 > \rho_3 <$	Clayey Sand
	5	5.4	---	---	$\rho_4 > \rho_5$	Peat
4	1	193.4	0.9	0.9	**QH**	Topsoil
	2	25.5	5.5	6.3		Clay
	3	6.9	**RESISTIVITY (Ωm)**	21.2	$\rho_1 > \rho_2 > \rho_3 <$	Peat
	4	36.6		---	ρ_4	Clayey Sand

VES No.	LAYERS		THICKNESS (m)	DEPTH (m)	CURVE TYPE	LITHOLOGY
5	1	220.3	231.3	0.8	**QH**	Topsoil
	2	42.4	63.1	6.5		Clay
	3	19.2	13.8	20.3	$\rho_1 > \rho_2 > \rho_3 <$	Clay
	4	91.9	---	---	ρ_4	Clayey Sand
6	1	212.9	0.7	0.7	**QH**	Topsoil
	2	44.0	3.1	3.8		Clay
	3	14.9	9.5	13.3	$\rho_1 > \rho_2 > \rho_3 <$	Clay
	4	77.1	---	---	ρ_4	Clayey Sand
7	1	75.8	0.9	0.9	**QH**	Topsoil
	2	18.5	1.4	2.3		Clay
	3	7.1	5.5	7.7	$\rho_1 > \rho_2 > \rho_3 <$	Peat
	4	92.5	---	---	ρ_4	Clayey Sand
8	1	88.7	0.7	0.7	**QH**	Topsoil
	2	29.0	2.3	3.1		Clay
	3	12.3	9.2	12.3	$\rho_1 > \rho_2 > \rho_3 <$	Clay
	4	82.2	---	---	ρ_4	Clayey Sand
9	1	7.8	0.8	0.8	**KH**	Topsoil
	2	53.0	7.3	8.2		Clayey Sand
	3	13.2	19.7	27.8	$\rho_1 < \rho_2 > \rho_3 <$	Clay
	4	90.0	---	---	ρ_4	Clayey Sand
10	1	41	0.9	0.9	**H**	Topsoil (Sandy Clay)
	2	29	7.3	8.2		Clay
	3	114	∞	∞	$\rho_1 > \rho_2 < \rho_3$	Sand
11	1	38	1.0	1.0	**KH**	Topsoil (Clay)
	2	129	1.2	2.2		Sand
	3	51	22.0	24.2	$\rho_1 > \rho_2 < \rho_3 >$	Clayey Sand
	4	240	∞	∞	ρ_4	Sand
12	1	116	1.0	1.0	**H**	Topsoil (sand)
	2	2	4.0	5.0		Clay
	3	36	∞	∞	$\rho_1 > \rho_2 < \rho_3$	Clayey Sand
13	1	41	0.7	0.7	**K**	Topsoil (Sandy clay)
	2	103	15.2	15.9		Sand
	3	60	∞	∞	$\rho_1 < \rho_2 > \rho_3$	Clayey

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