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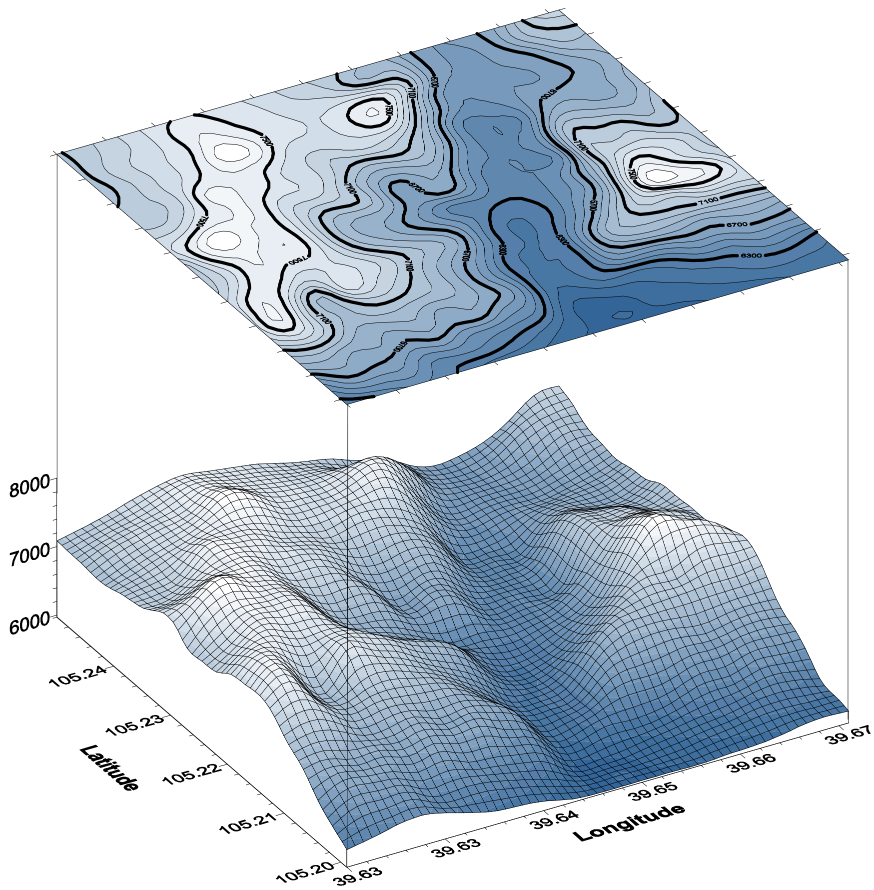
HYDROGEOLOGICAL REPORT

FOR SINGILA MAJENGO COMMUNITY



BY:

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Abstract

A ground water Resistivity survey was conducted at Mwatate; Singila- Majengo in an attempt to locate a fresh water reservoir after an previous drilling attempt at a nearby site drew saline water a depth of 3m.

The survey consisted of twenty VES current separation positions starting from 1.6m from the centre of the Schlumberger array to 63m. Potential separation points (MN) were spread from 1m to 10m also from the centre. The immediate surface portrays a very conductive medium typical of the clayly soils and carbonate deposition in the vicinity (overburden). A more resistive formation, however, occurs at depths ranging from 10 to 60m with values of between 3 and 50 Ωm.

The VES curve interpretation using the RES1D geophysical software depicts a prospective safe water aquifer depth of between 40 and 60m below the sounding site close to the paw-paw tree shown to plot owners.

The borehole site has been recommended for safe water harvesting as indicated in the conclusions and recommendations. An average of 15m^3 per hour is possible but this will be confirmed by the pump-testing. Environmental conditions are also discussed and the impact the borehole will create to the Flora and Fauna is referred to environmental experts for mitigation before drilling commences.

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Introduction

Mwatate area is located about 30km north-west of Voi town; a distance of about 200km from Mombasa. The physiography of the area is mainly scattered semi-arid scrub. Annual rainfall is about 1000mm and mainly comes in two major seasons.

The inhabitants are the Taita. Per capita income is approximately K.Sh. 50,000 where the main occupation is arable farming subsidized by labour work undertaken at farms nearby.

Average composition in a family is about five people but due to polygamous traditions accepted in the area, some families can have up to eighteen members. Religion is mainly Christianity of varying denominations.

Geology of Mwatate/ Chawia

The geology of the Taita Hills has been described by Horkel et al. (1979). The Chawia garnet-bearing rocks belong to the Mwatate Formation, a subdivision of the Kurase Group (Saggerson, 1962). In the Chawia area, as in its type locality (Pohl & Niedermayr, 1979), the Mwatate Formation consists chiefly of monotonous banded biotite (+/- hornblende +/- garnet) gneisses and migmatites with intercalations of graphitic gneisses, felsic gneisses, metalimestones and amphibolites.

According to Horkel et al. (1979), rocks of the Kurase Group were subjected to amphibolite facies metamorphism in the sillimanite stability field, with P-T conditions of 630 to 700^{o}C and 3.5 to 7.5 kbar. Goerg et al. (1982) in a study of V-grossular ("tsavorite") bearing graphitic gneisses of the Kurase Group estimated that this mineral crystallized with diopside at temperatures of 550-580^{o} C and pressures of 3-5 kbar.

However, some rocks of the Kurase Group also recorded higher grade metamorphism. Key & Hill (1991) proposed that the tsavorite deposits located in the Lualenyi Member of the Kurase Group formed under granulite facies conditions. Further south in Southern Kenya, the occurrence of minerals such as sapphirine (Mercier et al., 1999) and kornerupine (Simonet, 2000) in rocks of the Kurase Group also points towards granulite facies metamorphism. Mercier et al. (1999) showed that at least part of the corundum deposits of the Mangare area formed under granulite facies conditions.

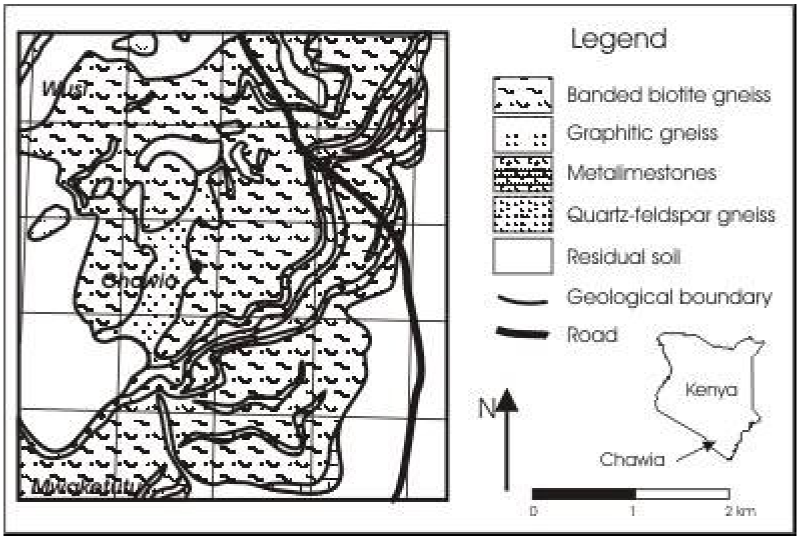


Fig. 1. Geological map of the Mwatate/ Chawia area (after Horkel et al. (1979)).

The Chawia deposit is hosted in one of the graphite-bearing units of the Mwatate Formation (figure 1), which was the target of graphite exploration in the late 1970s. The main graphitic horizon reaches six to ten meters in thickness and is remarkably continuous along the strike, over a distance of several kilometres (Horkel et al., 1979), with a uniform dip at 10 to 20 degrees towards the NNE. It is the host of the garnet mineralization, which is developed on a distance of at least two hundred meters.

The graphitic gneiss is leucocratic and locally boudinaged. Graphite occurs as disseminated flakes and spherules in the rock. In thin section, the rock is fine grained and consists mostly of quartz and sericitized alkali feldspar. Phlogopite, altered pyrite, and numerous graphite flakes are scattered in the rock. Small rounded grains of garnet are also present in quartz-rich areas.

Garnet is recovered from only one horizon of the gneisses, and is not distributed throughout. The mineralization is irregular and consists of porphyroblasts associated with elongated quartz stringers parallel to the foliation of the gneisses. These metamorphic segregations have a darker rusty color because of the oxidation of accompanying pyrite. Under the microscope, garnet appears as large porphyroblasts in a quartz-pyrite matrix. Pyrite is almost totally oxidized into a mixture of hematite and Fe-hydroxides. Garnet grains contain inclusions of graphite, phlogopite, quartz, and subhedral apatite.

Mineralogy

Electron microprobe analysis was performed on several garnet samples of different color. Molar proportions vary from one sample to the other, and appear to be closely related to the color of the gemstones. Light green garnet samples are richer in grossular (17-18.4 mol % grs) than grey samples (1.8 mol % grs).

The Chawia garnets are thus quaternary solid solutions of grossular, pyrope, spessartite and almandine, with minor amounts of andradite, goldmanite and uvarovite (figure 2). They all contain traces of Cr and / or V (Cr_2O_3 = 0.01 to 0.17 wt. % and V_2O_3 = 0.10 to 0.32 wt. %). V content is relatively constant (around 1 mol% goldmanite) except in sample csg5, and is always higher than Cr content.

Chemically similar gem garnets have been described from alluvial deposits in Tanzania (Umba area - e.g. Crowningshield, 1970; Tunduru-Songea area - Henn and Milisenda, 1997), from Madagascar (Zylberman, 1999, Krzemnicki et al., 2001), Sri Lanka (Gübelin & Schmetzer, 1982; Johnson & Koivula, 1998), and from other unknown sources (Stockton, 1982; 1985; Manson & Stockton, 1984). All these gemstones have change-of-color properties.

On a FeO vs. Cr_2O_3+V_2O_3 diagram, the Chawia garnets plot within the area defined by the 32 change-of-color pyrope-spessartite solutions studied by Manson and Stockton (1984), except sample csg5 (figure 3). The later is the richest in grossular (18.4 mol % grossular) of our samples, and in this respect compares with gem change-of-color garnets from an unknown source described by Stockton (1985).

1. Geophysical VES sounding technique

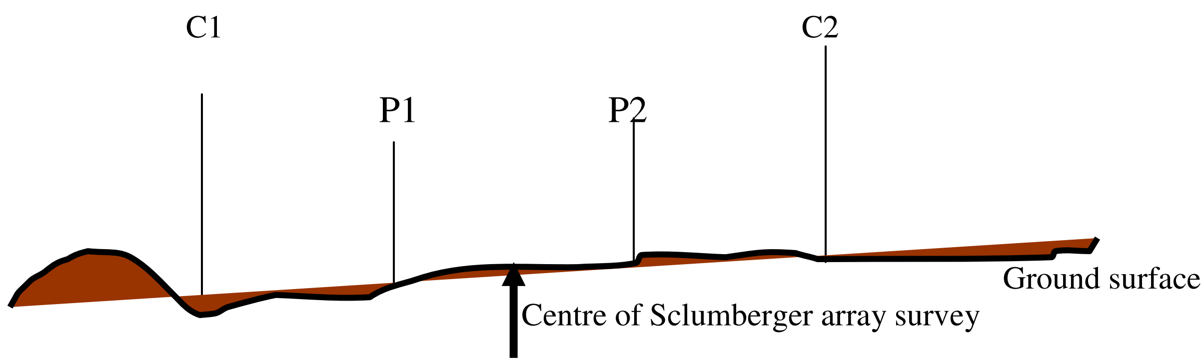


Fig. 2. Schlumberger array for ground water prospecting

The Schlumberger array for vertical electric sounding technique was used in this survey (fig. 2). This method involves the introduction of a low frequency AC current into the ground and receiving the potential difference generated in response. The two current electrodes (steel) are positioned symmetrically about the station under investigation. These electrodes introduce high voltage current into the ground to energize any conducting formation in the sub- surface.

The potential electrodes (P1 & P2) are maintained closer to the centre as the C1 & C2 current electrodes are moved further apart to the left and right. This action leads to a relationship of lateral distance with depth being investigated. The true depth in this case varies from 100% on the shorter current separations to 50% for wider separations. Ohms law states that;

$V=IR$ and $R=\rho l/A$

Where V is received potential, I is transmitted current and R is the ground resistance. The resistivity, ρ, is the factor required in this technique where l is length of conducting body and A its surface area.

Thus, $\rho = k\Delta V/I$ (Ωm) where k is the geometric factor arising from the electrodes separation.

The parameters registered in this method are thus; potential received, the current transmitted and the electrode separation. The potential electrodes are made of copper. Copper sulphate (saturated) solution is poured on the ground to improve contact and minimize local action by undergoing electrolysis.

Discussion of results

The results of the survey appear in the logarithmic plot after rigorous interpretation of the raw data with a geo-physical software called RES1D. The package is able to convert resistivity, IP and SP data into logarithmic displays where the sub-surface can be analyzed with respect to potential (SP), chargeability (IP) or resistivity (Wenner or Schlumberger arrays).

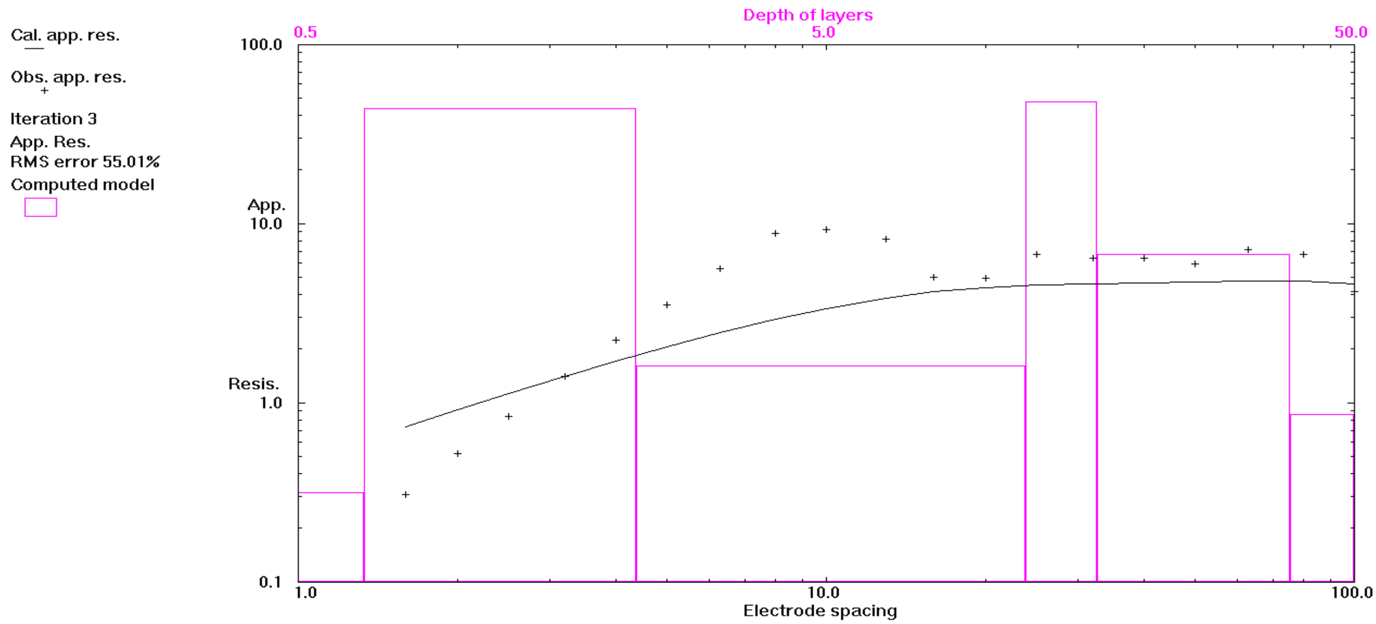
After several iterations (see fig. 3 below), the program gave a four layered earth model with varying resistivities in the area of study. Emphasis in this package is laid on the interpretational skills of the operator and the more the models considered the better the desired result. A summary of the result is as follows;

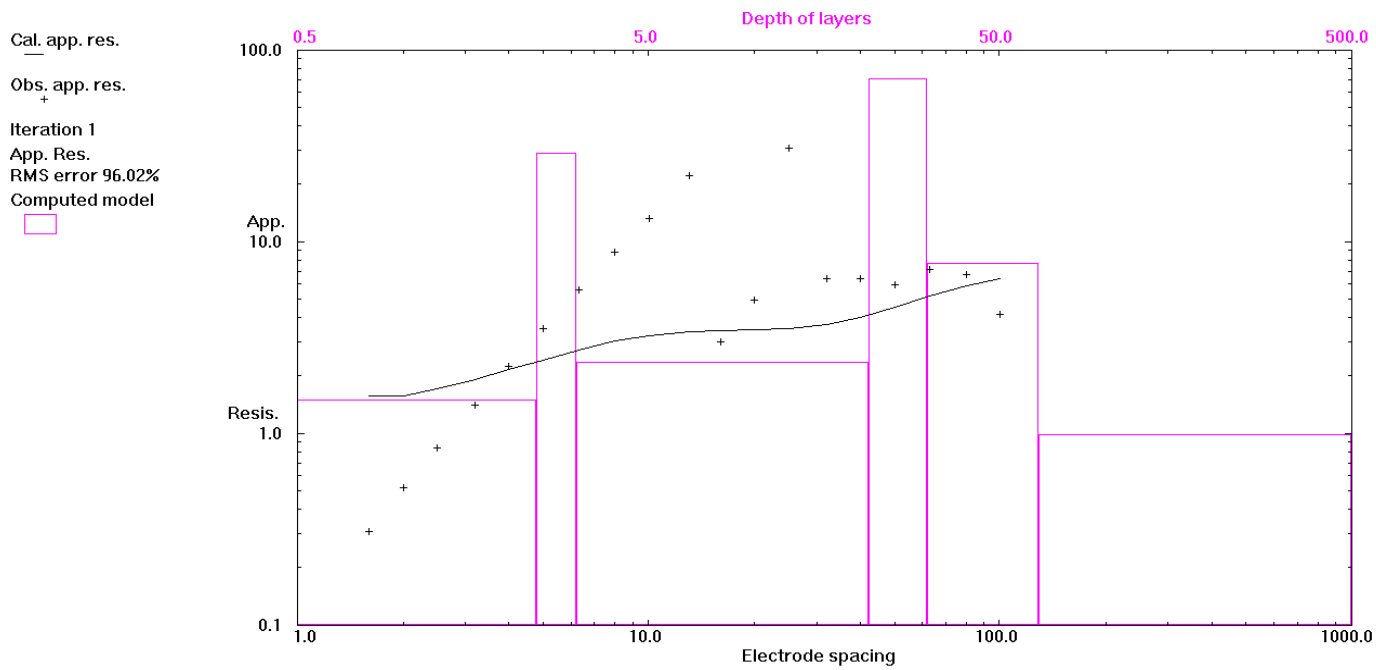
Layer	Thickness	Resistivity	Possible formation
1	10m	10 Ohm-m	Black Clayly soils,overburden
2	5m	300 Ohm-m	Weathered porous carbonate Loose Aggregate
3	35m	70 Ohm-m	Weathered basement
4	Beyond 60m	500 Ohm-m	Basement

There was some difficulty in trying to calculate the best fit regression line as the data presented seemed to bear a lot of overlapping of formations, especially at the near- surface. The least squares method used proved helpful in zeroing on the desired accuracy to obtain a plausible explanation on each formation so delineated.

There is hence a major possibility of hitting fresh water between 25 and 60m but beyond that, chances of encountering the base rock are high. The weathered graphitic gneiss provides good permeability levels for water transmissivity. This is the main aquifer.

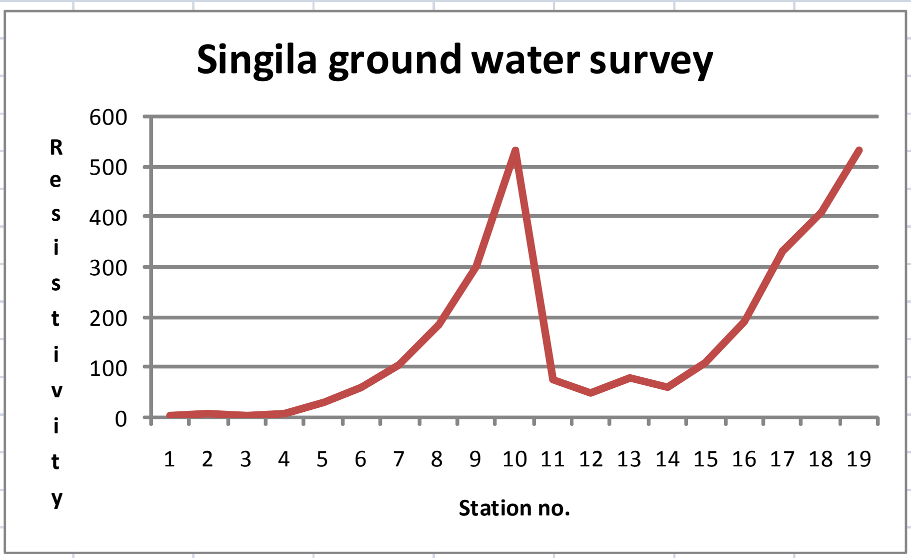
Fig. 2. Interpretation of Geophysical Resistivity data.





Singila Majengo ground water survey 21/03/2011

AB/2 (m)	MN/2 (m)	K	△V (mV)	ρ (ohm-m)
1.6	0.5	7.26	0.61	4.4286
2	0.5	11.8	0.46	5.428
2.5	0.5	18.8	0.18	3.384
3.2	0.5	31.4	0.28	8.792
4	0.5	49.5	0.63	31.185
5	0.5	77.8	0.75	58.35
6.3	0.5	124	0.83	102.92
8	0.5	200	0.91	182
10	0.5	313	0.95	297.35
13	0.5	530	1	530
16	5	72.6	1.04	75.504
20	5	118	0.42	49.56
25	5	188	0.41	77.08
32	10	145	0.4	58
40	10	236	0.46	108.56
50	10	377	0.5	188.5
63	10	608	0.54	328.32
80	10	990	0.41	405.9
100	10	1560	0.34	530.4



Conclusions and recommendations

The survey for ground water was successful as it identified various formations to be encountered while drilling. Four different major formations are possible in the subsurface as detailed in the geology. The fresh water reservoir here may be encountered from a depth of 30m or less but ends at about 60m below the VES station. Percolation of fresh meteoric waters whose recharge is basically from normal precipitation is a possibility in the weathered Graphitic Gneiss and especially where fractures and faults are abundant.

It is thus recommended to drill a borehole for safe water at the VES site. A maximum depth of 60m is envisaged beyond which only the compacted Gneisses will be encountered.

Casings of 6’’ size will be used from top to bottom to prevent permeating of waters from the surface clays. Where the reservoir is clearly identified, perforated casings (PVC) will be used. The borehole design will bear the normal finishing as recommended by the water resource body. A piezometric line will be fitted to monitor the water level; a master meter of appropriate diameter will also assist in the water volume assessment.

Recommended also is a Gantry, and a block and chain to be fitted overhead for further use whenever required, be it in borehole cleaning or monitoring. An Environmental Impact assessment report will also be done to address mitigation, if any.

Data

Schlumberger Logs Array Type (Wenner or Schlumbeger) **Schlumberger**
Number of data points **19**
Data Type (Resistivity,IP,SIP) **Resistivity**
Error in measurements included (Yes,No) **No**
Data section
1.6 1.0 0.010
2.0 1.0 0.015
2.5 1.0 0.023
3.2 1.0 0.046
4.0 1.0 0.094
5.0 1.0 0.136
6.3 1.0 0.243
8.0 1.0 0.475
10.0 1.0 0.746
13.0 1.0 1.113
16.0 1.0 1.955
20.0 1.0 2.967
25.0 1.0 4.818
32.0 1.0 11.293
40.0 1.0 19.782
50.0 1.0 31.397
63.0 1.0 36.527
80.0 1.0 39.8
100.0 1.0 67.767
User Starting Model Available (Yes/No) **Yes**
Fix Parameters (Yes/No) **No**
Number of model layers **6**
Model Parameters
3.8,4
14.43,9
30.13,12
60.321,55

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