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Application of Resistivity Surveys to Assessthe Subsurface Characteristics of Dolerite Dykes

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ABSTRACT

The resistivity data were collected to identify the subsurface dimensions of the dykes and the results of the resistivity analysis confirmed that the dykesextend to the depths in almost vertical plane, with dip angle close to $90^0$with no disturbances.

This study confirms that the resistivity technique is applicable in the identification of the dimensions of a dyke to a limited depth. The results of the resistivity studies of dykes serve as auxiliary information to fix the inversion parameters ofdeep geophysical analyses.

Key words: *1D and 2D resistivity survey, Subsurfaceextension, Dyke, Dip angle, Elevation profile.*

1.0 INTRODUCTION

Dolerite dykes are late intrusions and the cross cutting nature of the country rock is prominent[1,2]. However, the dykes dominate in the Vijayan Complex and almost terminate towards the Highland complex margin[1,2]. This suggests that the extensional forces acted upon the two complexes during the formation of dykes were different. The Vijayan crust is probably thinner thanthe Highland crust where intrusions easily penetrated to the surface. Further, the rock competency of two complexes may differ as the Highland rock is composed ofmore high pressure mineral assemblages (garnet-sillimanite-biotite) in extreme dry conditions than the Vijayan lithology[1,2].

The igneous intrusions intruded into the Vijayan Complex lithologyin the form of dolerite dykesare characterized by fine grained black mineral assemblages composed of high amount of ferro-magnesiumconstituents[3-6]. The dykes extend along SSE-NNW direction as linear features over 60km with nominal width of 7-10 m, with seldom sporadic bulky occurrences. Two major dolerite dykes have beenidentified and mapped with an extension over 50km running almost parallel to each other with a separation of 40km[1,2]. Apart from the major two dykes, the dolerites appear as short extensions which follow the same direction as the major two dykes, in many instances[2].

The subsurface characters of dykes, particularly the dip direction is one of the major parameters that influences the geological and geophysical studies. By the definition of the dyke and considering the linear and extending character of Sri Lankan dykes with confined width it is suggested that the dyke itself extends from the surface to the source;

deep-seated hot environment, with no interruption[7]. The subsurface characters of the dykes can be confirmed without any doubts by drilling through the formation based on the results of geophysical techniques. However, drilling is a costly affair as almost always replaced by other alternative methods.

The resistivity techinque has been identified as one of the locally available alternative methodsin identifying the subsurface characters of dykes.Though there are few drawbacks such as limitationin the depth detection etc., both 1D Vertical Electrical Sounding (VES) in Schlumberger array, and 2D resistivity imaging in Schlumberger-Wenner combined arrays were performed in the field as reported in the literature [8,9].In this study, the weathered overburden thickness, the dip direction and the dip angle of the dykes were estimated using the resistivity technique.

2.0 METHODOLOGY

ABEM Terrameter model 300 SAS was used in the field for 1D data acquisition process. Schlumberger array was selected as the suitable electrode configuration and the potential electrodes were kept at a constant separation and were changed only when a greater potential difference is required to drive current into the ground. The electrode spread is comparable to the depth and this method enables acquiring data along the central plane of the Vertical Electric Sounding (VES)location similar to an augur hole[8,9].

2D resistivity imaging was conducted using AGI (Advanced Geosciences Inc.)Mini-sting system at selected study sites along the dolerite dyke. Resistivity imaging technique was applied to verify the results obtained from 1D technique and to delineate the subsurface characters of the dolerite dyke with depth extension. The two data sets acquired in 1-D and 2-D resistivity techniques were integrated in final analysis to have a better control of the interpretation work[8,9].

2.1 Data collection

The data were collected in predefined sites during the period from 04th April 2013 to 01st November 2013 and the study sites are shown in the Fig.1.The locations where the weathered dolerite boulders are exposed or the bulk of the dolerite dyke is covered by a thin layer of overburden material were selected as study sites. The resistivity measurements of the background rocks were also taken in order to compare and contrast resistivity results of dykes.

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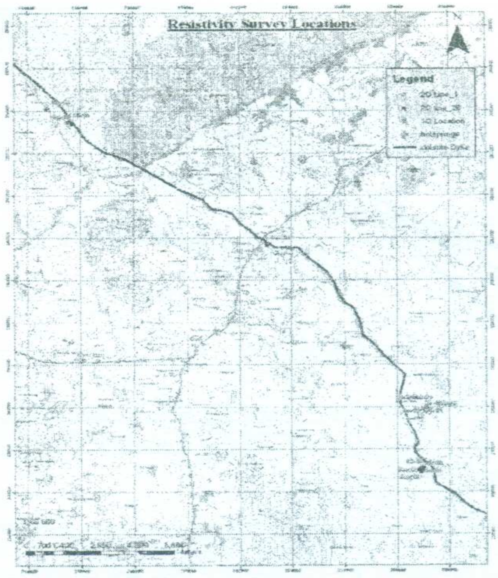

Fig. 1: Study locations of the resistivity surveys

3.0 RESULTS AND DISCUSSION

3.1 1DVertical electrical sounding surveys

Vertical Electrical Soundingsurveys were conducted in selected sites, which are situated in Wahawa area and Maduruoya national park. Table 1 shows the vertical electrical sounding locations and their coordinates.

Table 1: Vertical electrical sounding locations

ID	E	N	Description	Legend title
Series 1	259024	237088	Wahawa Dyke	1D- 01
Series 2	258941	237009	Wahawa (background)	1D- 02
Series 3	245557	253474	Maduruoya Dyke Location 01	1D- 03
Series 4	244783	254099	Maduruoya Dyke Location 02	1D- 04

The resistivity variation of the dyke compared to its background geology is shown in Fig. 2. The series 2 shows the background resistivity values (raw data) near the Wahawa dyke whereas the series 1, 3 and 4 show the resistivity values at the dyke exposures of Wahawa and Maduruoya.

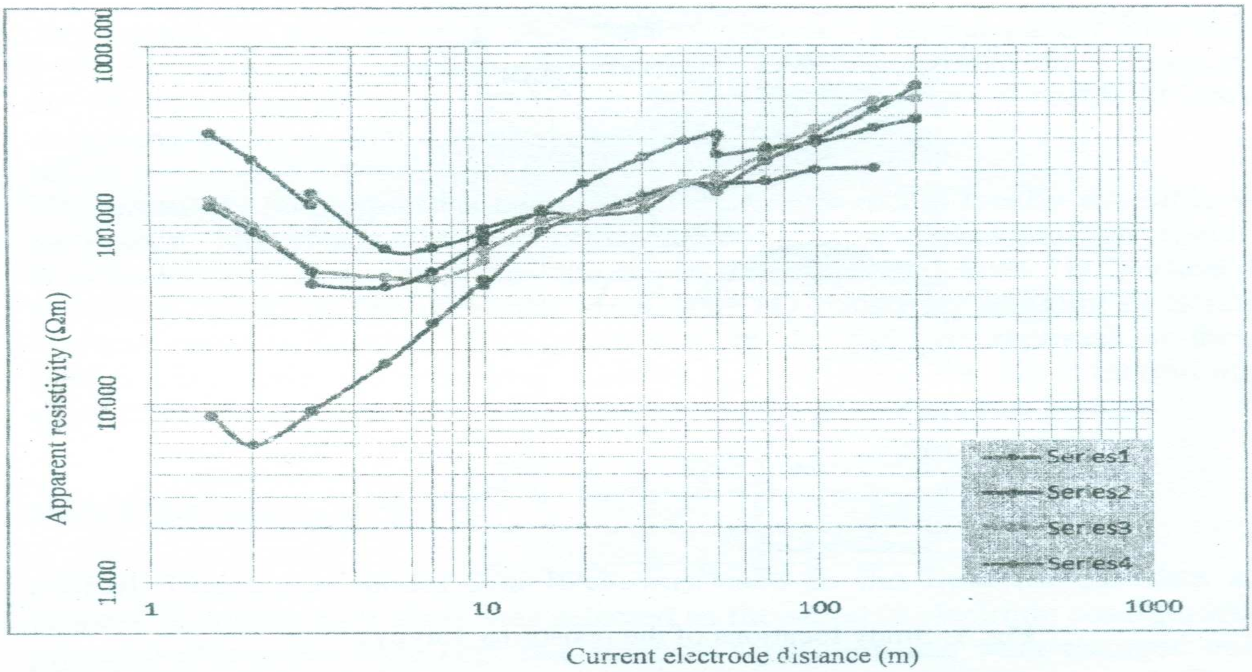

Fig.2: Vertical electrical sounding curves

The 1D resistivity data analyses were performed using Resist free- software to construct the subsurface model. It could be observed that the trend of the curves at locations on the dyke exposures is almost comparable and hence only one selected vertical electrical sounding profile and that of backgroundgenerated using the Resist free- software are given in Figure 03 and 04 respectively.

Fig.3 shows the subsurface extension of the Wahawa dyke at the location of 259024E, 237088N. At a depth of 2.3 m (1.1 m+1.2 m), a very high resistivity value could be observed indicating the presence of a fresh dyke extending to the depths.

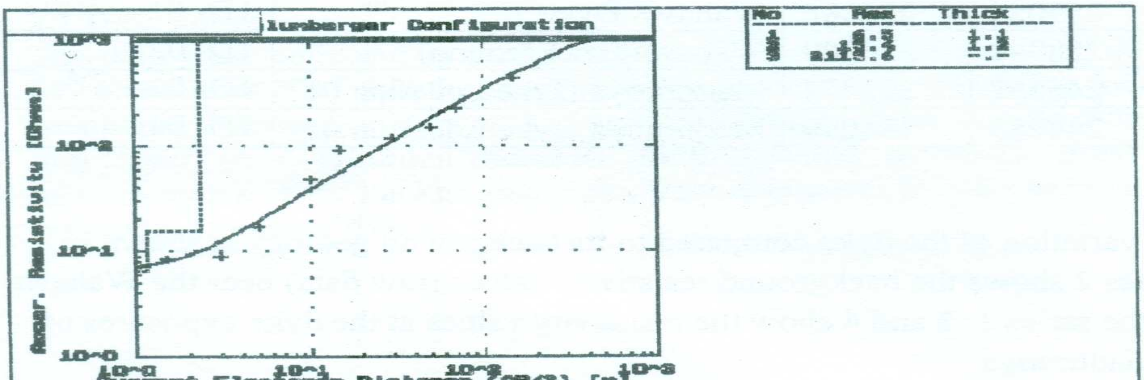

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Fig.3: Vertical electrical sounding profile in dyke at Wahawa; Location: 259024E, 237088N

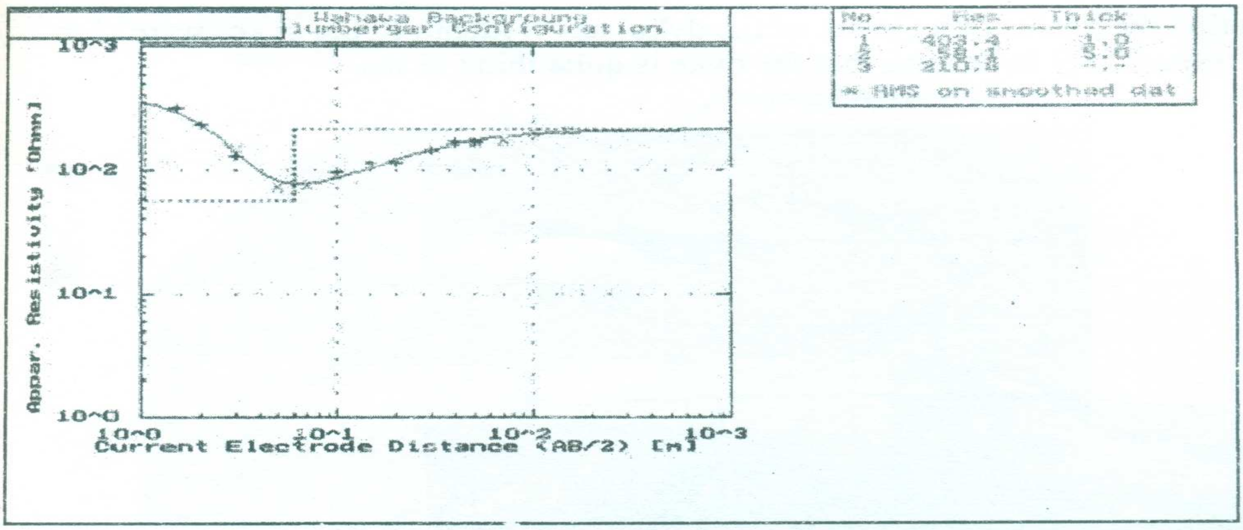

Fig.4: Vertical electrical sounding profile in background of the dyke at Wahawa; Location: 258941E, 237009N

The vertical electrical sounding profile in background of Wahawa dyke is given in the Figure .04. The resistivity value of this site is very low compared to the site corresponding to the Figure 03. Therefore,very high resistivity contrastcould be observed betweenthe dyke and the background geology, since the dolerite is a fine grained intrusion composed of ferro-magnesium minerals and its fracture free nature.

3.2 Correlation of 2D and 1D resistivity analysis with dyke orientation

2D resistivity data were processed for all the study sites mentioned in the Fig. 1. However, only two selected study sites were presented in this paper, since the same characteristics were observed in almost all the sites.

Based on the results of the resistivity analysis, and considering the origin of dykes, the following model is proposed to explain the subsurface extent of the same.

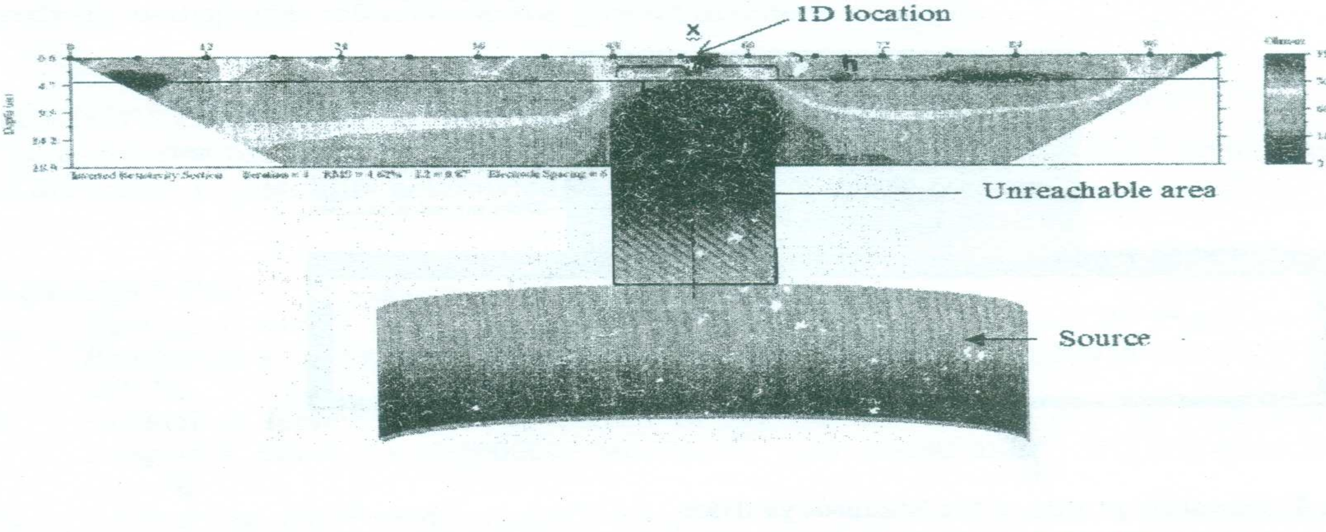

Fig.5: 2D resistivity profile at Wahawa Location: (258823E, 237040N), (258942E,237112N)

In this location the values of x (width of the dyke) and h (depth to the dyke) were 12 m and 2.3 m respectively indicating that the dyke is quite thin (12 m).

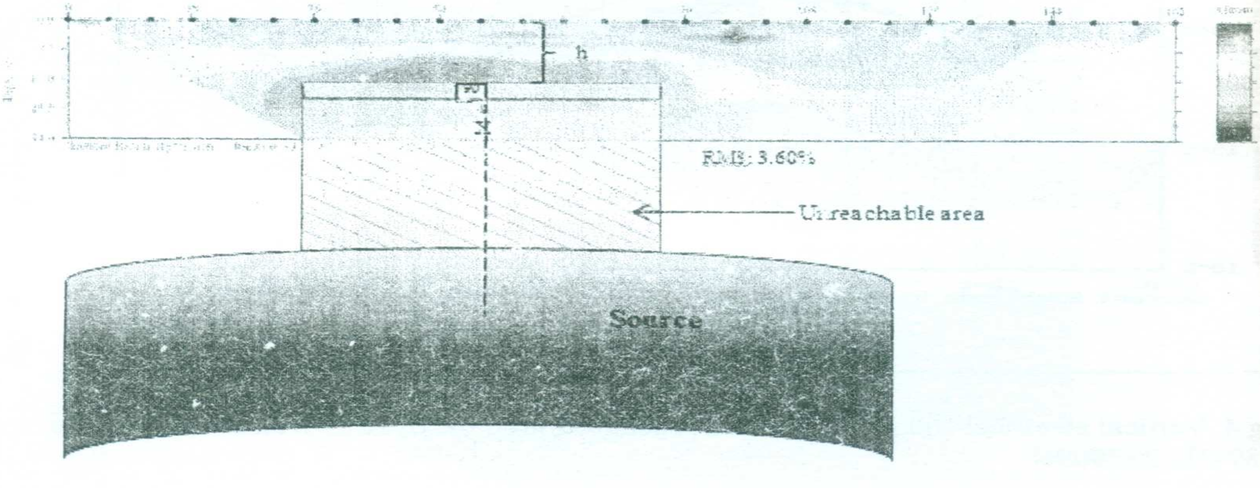

Fig.6: 2D resistivity profile at Wahawa area Location: (259101E, 239915N),(259245E, 239835N)

In this location the values x and h were 45.0 m and 12.0 m respectivelyindicating that thedyke is thicker (45 m) compared to the previous location.
Figure 05 andFigure 06clearly show the variation of width and depth to the fresh dyke surface. However in all these 2D profiles dip angle was constant and it wasalmost 90°.

3.3 Elevation profile across the dolerite dyke
The elevation profileswere constructed using satellite images and the elevation profile of Maduruoya dyke near the 1D location is shown in the Fig. 7.

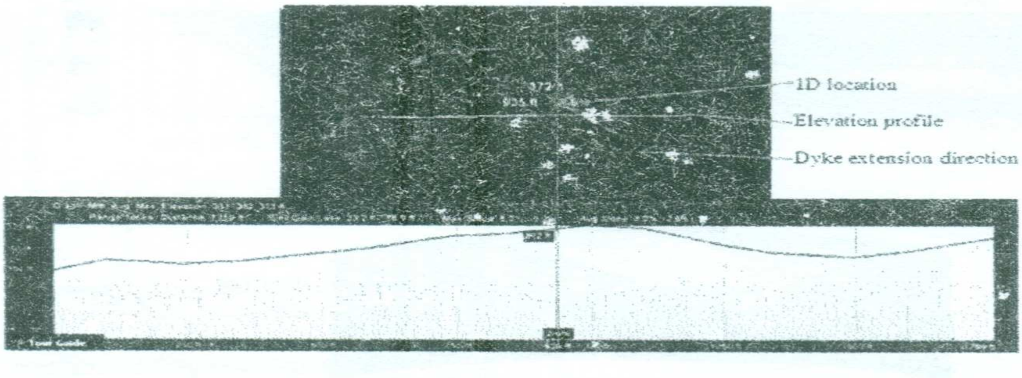

Fig. 7: Elevation profile of the Maduruoya dyke

4.0 CONCLUSION

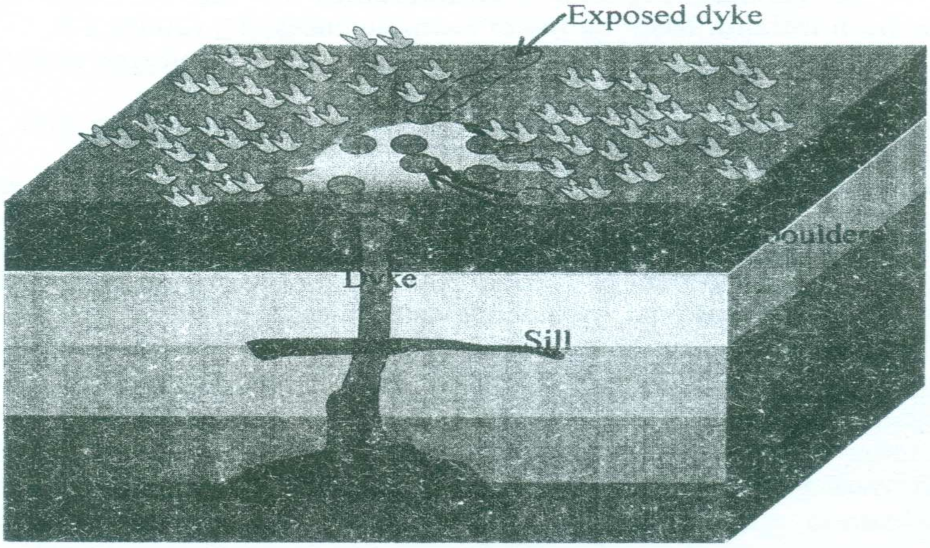

Fig.8: Schematic diagram of the subsurface extension of the dolerite dyke

It is concluded that the dolerite dykes at the study sites extend beyondthe depth of investigation with almost a vertical dip with no interruption. Width and the depth to the dyke vary in different locations depending on local weathering conditions and background geology. The resistivity technique provides necessary parameters of the dyke enabling to model the same with higher degree of certainty.

This study confirms that the resistivity technique is applicable in identifying the dimensions of a dyke to a limited depth. The results of the resistivity studies of dykes serve as auxiliary information to fix the inversion parameters of deep geophysical analysis, withspecial reference to the ground magnetic analysis.

ACKNOWLEDGEMENT
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