Validity of an Empirical Rule for Delineating Aquifer Prospects at the Gidan Kwano Campus Development Phase II, Federal University of Technology, Minna, Northcentral Nigeria.

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Validity of an Empirical Rule for Delineating Aquifer Prospects at the Gidan Kwano Campus Development Phase II, Federal University of Technology, Minna, Northcentral Nigeria

Jonah, S.A. and *Jimoh, M.O.

Department of Physics, Federal University of Technology, Minna, Nigeria

*Department of Geology, Federal University of Technology, Minna, Nigeria

Abstract

There exists an empirical rule to determine the likely presence of groundwater in a local Basement Complex geological province but there has not been an independent analytical approach to test this rule yet. Result from a 4km^2 two-dimensional VES survey was analysed according to standard procedures and pseudosections along principal profiles were generated. From a handful of these pseudosections selected for this study, it is observed that the basis of this rule is true when aquifer delineation is aided by computer-assisted processing; thus, it is recommended that where the means to analyse VES data for small-scale surveys by computer software are not readily available, recourse to the "Geoexplore Empirical Standardisation for Minna Area" should be adopted when working in a Basement Complex province.

Keywords: Basement; empirical; log-log; iso-resistivity; pseudosection

Introduction

Surveying for groundwater prospects at the Basement Complex of different geological provinces (the "Sheets") have spurned a couple of independent observations by practicing geoscientists that led the author to construct an empirical rule that has been a useful guide or pointer to identifying these prospects wherever a study is carried out. The author calls this empirical rule the "Geoexplore Empirical Standardisation for Minna Area." The "Geoexplore Empirical Standardisation for Minna Area" states that resistivity values between 200Ωm and 300Ωm at the 20m depth and less than 200Ωm at depths greater than 20m are indicative of possible groundwater prospect. This rule was the basis for the interpretation of the results of the surveys of Jonah *et al.* (2013), Jonah *et al.* (2014A), Jonah *et al.* (2014B), Jonah *et al.* (2014C), Jonah *et al.* (2014D), Jonah *et al.* (2015A), and Jonah *et al.* (2015B); in fact, the recommendation of the survey of Jonah *et al.* (2014D) have led to a successful water-borehole scheme for the client. With respect to geoelectrical studies that have been carried out at the local Basement Complex of which the location of this study is a part, the following works are also cited: Abdulrashid (2005); Salako *et al.* (2010).

The purpose of this study is to test for the validity of this empirical rule at the Gidan Kwano Campus Development Phase II, Federal University of Technology, Minna, Northcentral Nigeria. The location most suited for the Phase II Development at the Gidan Kwano Campus is an 8km^2 areal extent defined to be a perfect rectangle on the ground with its ends corresponding to the following georeferenced co-ordinates: $09^{0}30'57.8''$N, $006^{0}25'39.0''$E (most extreme southwest); $09^{0}30'57.8''$N, $006^{0}26'43.8''$E (most extreme southeast); $09^{0}33'07.4''$N, $006^{0}26'43.8''$E (most extreme northeast); $09^{0}33'07.4''$N, $006^{0}25'39.0''$E (most extreme northwest). A half-scale survey of 4km^2 areal extent at the southern end of this 8km^2 areal extent has been completed for this study and the schedule of survey points where data was collected has been colour-coded in the layout of Fig.1; the dots of Fig.1 are separated by 100m.

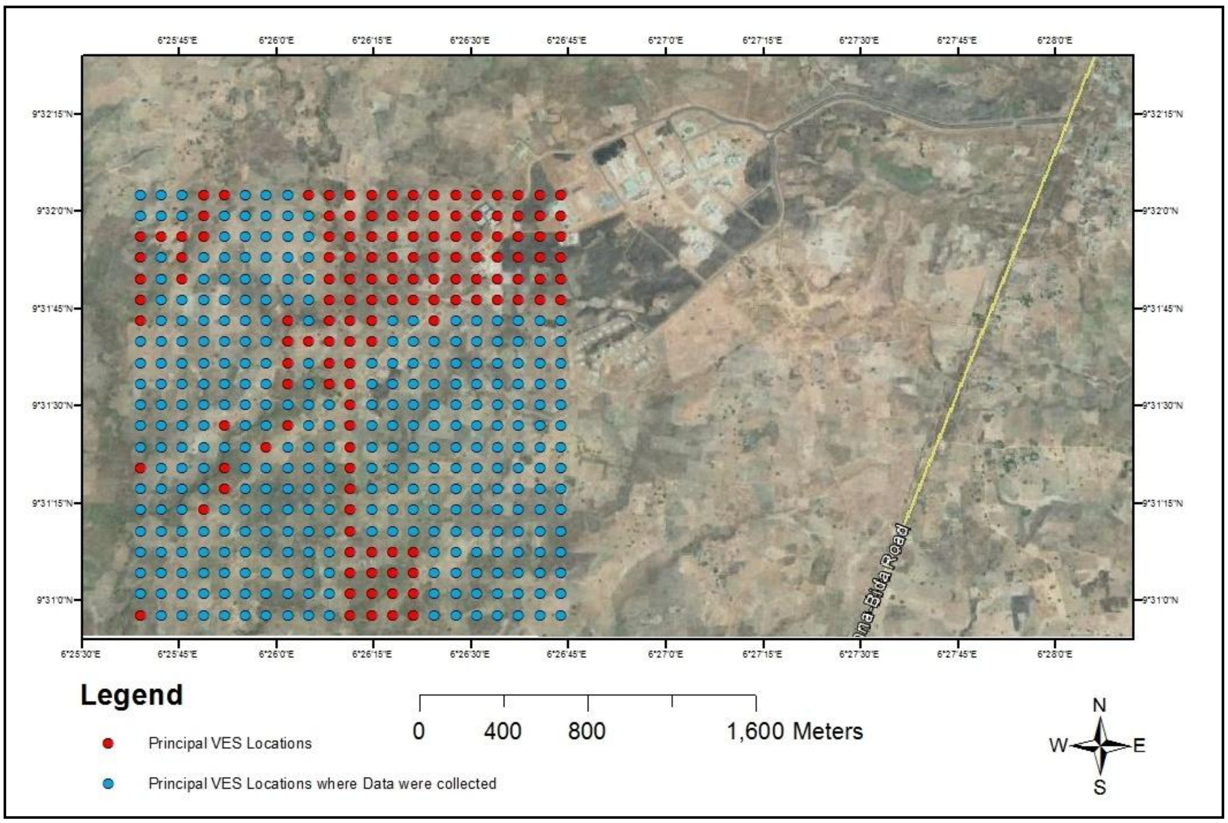

Fig.1. Locations of the principal stations of the 4km^2 tranche of new development colour-coded for points where data was collected

Methodology

The Schlumberger array of the vertical electrical sounding (VES) mode, at 100m station-spacing, was employed for the survey. The survey trend was an east-west (or transverse traverse, TT) sense for individual stations and a south-north profile, thus defining a two-dimensional configuration. The station-designation format for this study also follows a two-dimensional spatial awareness: principal profile lines are in the north-south direction, with the first profile line being the westernmost line of longitude; numerical station-designation is from west to east. The actual field survey proceeded from south to north because it was most convenient for the survey crew as the southwestern portion of the area of study was considered the most distant from the staging point and thus the most "difficult" to tackle; this "difficulty" had to be tackled first. Thus, the first assigned station of survey based on this format is the most extreme southwestern point in the 2km by 2km grid appropriately called P1-1; that is, Station 1 of Profile 1. Station 2 of Profile 1 (P1-2) is exactly 100m to the north of Station 1; Station 3 of Profile 1 (P1-3) is exactly 100m to the north of Station 2 and exactly 200m north of Station 1, and so on. P2-1 means Station 1 of Profile 2; this is exactly 100m to the east of P1-1; P3-1 is exactly 100m to the east of P2-1 and exactly 200m to the east of P1-1. Along the P11 traverse of Fig.1, the available data-set was acquired in the longitudinal traverse (LT) mode in the year 2011; thus that particular data field was not included in this TT analysis.

Data Processing

Production of the Log-log Plots. The field resistivity values were initially subjected to the log-log plot routine of the Windows-compatible WinResist® software whence corresponding field curves for all the stations occupied were produced; each of the resulting *circa* 300 WinResist® log-log plot provides information on the numbers of layers, the average resistivity values of these layers, and their approximate thicknesses.

Production of Iso-Resistivity Maps at Depths. In order to show the variation of resistivity on a constant plane across the area of study for this VES survey, the Surfer-11® software was used to generate iso-resistivity maps at 1m, 10m, 20m, 30m, 40m, 50m, 60m, 70m, 80m, 90m, and 100m depth-marks.

Production of the Pseudosection Plots. In order to show the resistivity cross-section along a principal north-south profile, the Surfer-11® application was also used to produce the equivalent pseudosections.

Analysis of the Pseudosection Plots:- Only the plots of P1, P4, P14, P16, P18, and P20 would be employed here to test for the validity of the "Geoexplore Empirical Standardization for Minna Area" because of *the observed convenience of the lowest resistivity trend occurring at depth for all these profiles for the predominant mode of computer monitor colour display*; however, when these plots are viewed out of the predominant colour mode, the new pattern correlates very strongly with the observation that is overwhelmingly correct. These plots are shown as Figs 2 to 7.

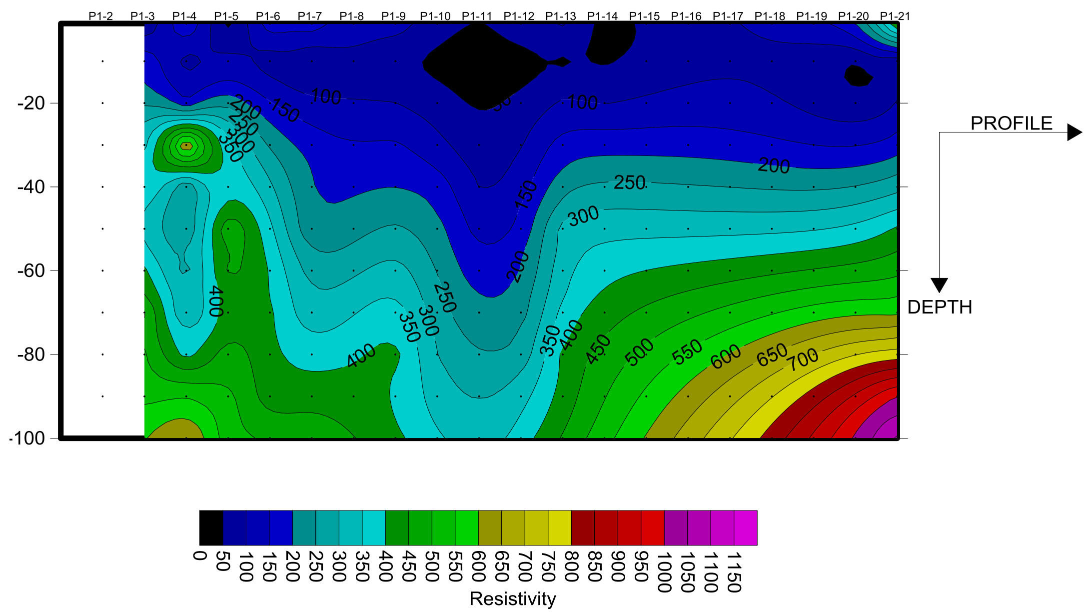

Fig.2. Pseudosection plot for P1

The Pseudosection Plot of P1:- A synclinal high-resistivity material of fractured basement character is observed to have its low-resistivity trough centred on P1-10, P1-11, and P1-12 with its “minima” obviously on P1-11.

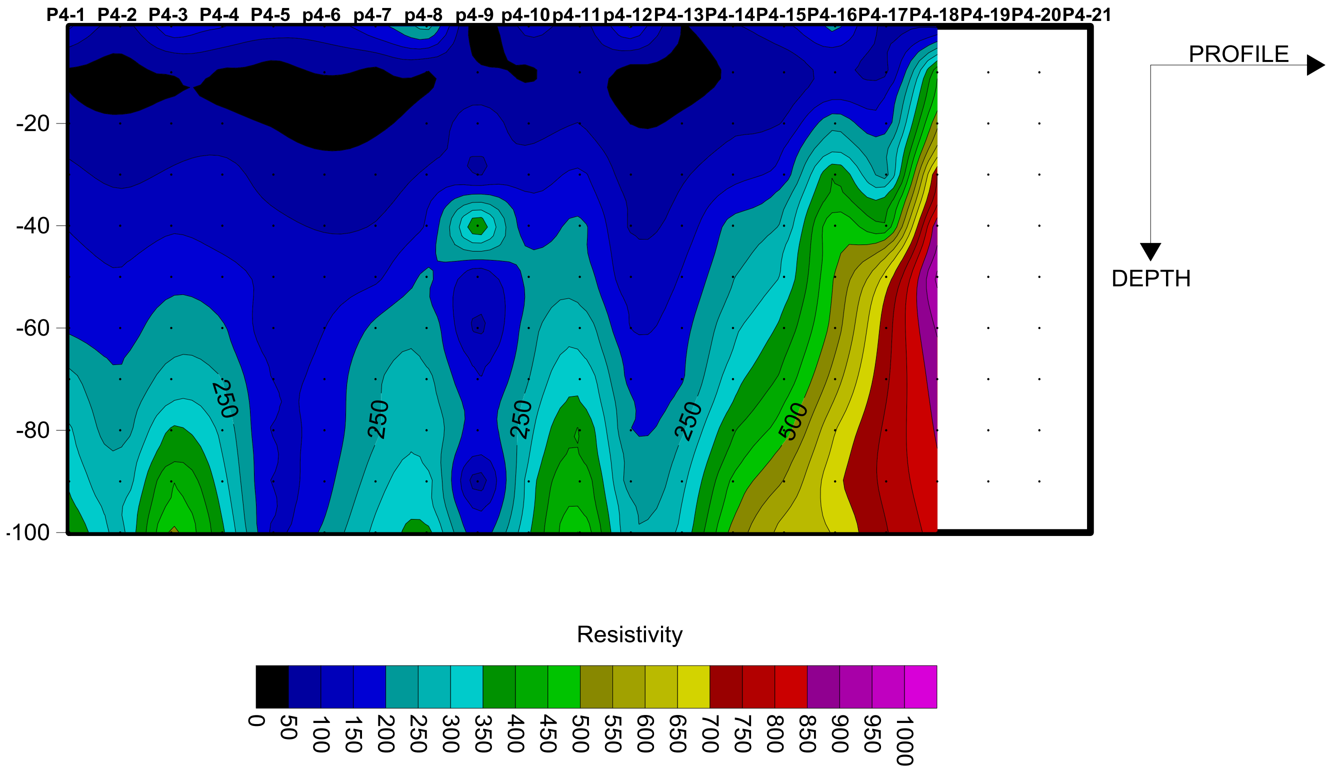

Fig.3. Pseudosection plot for P4

The Pseudosection Plot of P4:- A deep-seated fracture structure is observed at P4-5, P4-9, and a synclinal high-resistivity material of fractured basement character is observed to have its low-resistivity trough centred on P4-2 and between P4-12 and P4-13.

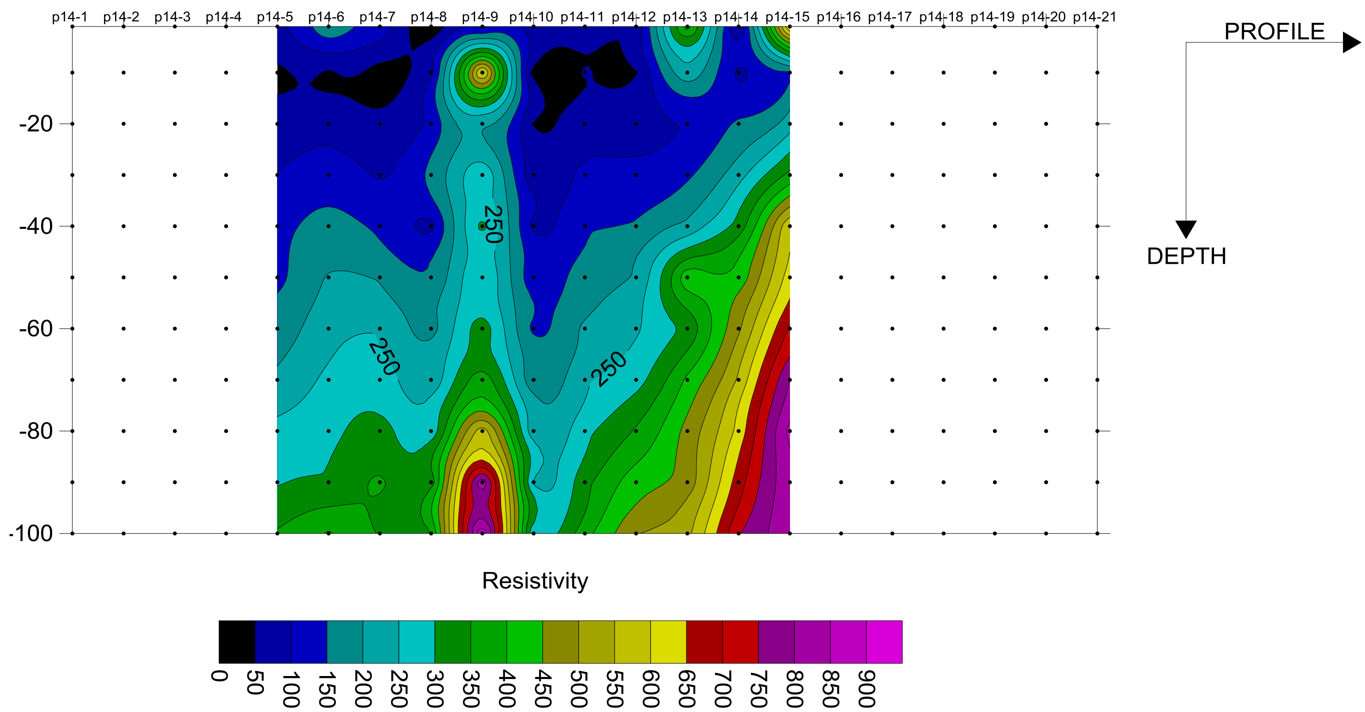

Fig.4. Pseudosection plot for P14

The Pseudosection Plot of P14:- A synclinal structure of comparatively high-resistivity is observed to have its low-resistivity trough centred on P14-8 and P14-10; observed at P14-5 is a vestige of a similar structure.

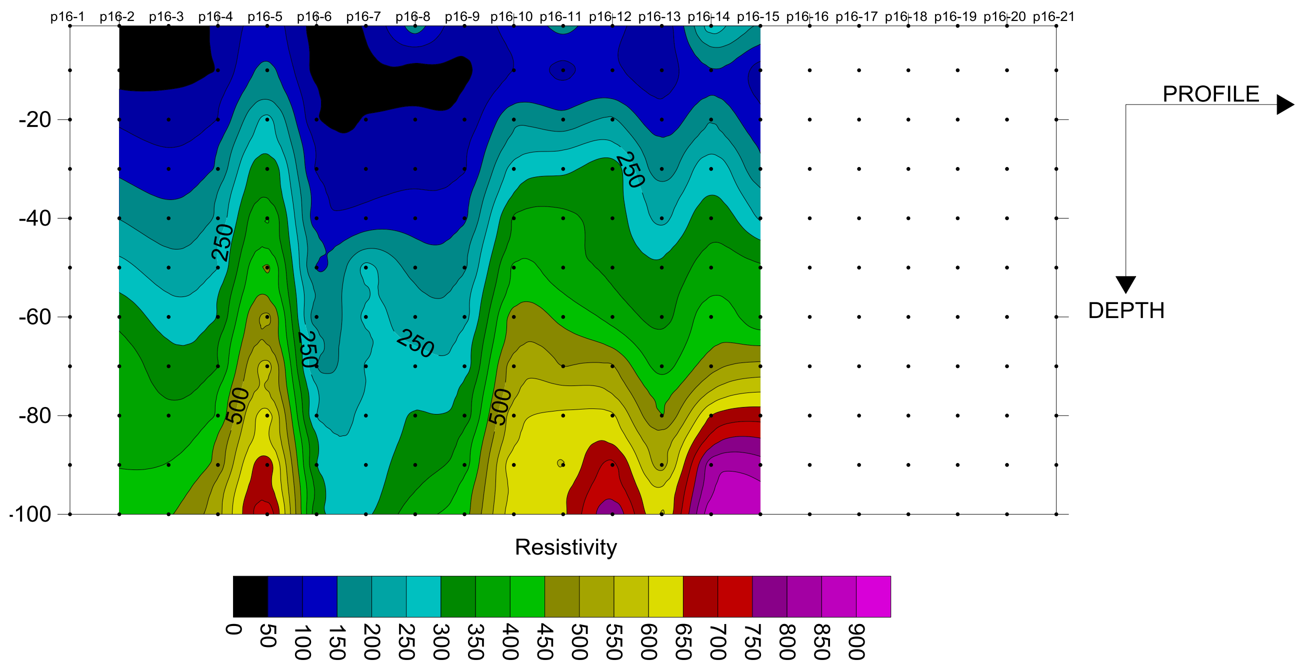

Fig.5. Pseudosection plot for P16

The Pseudosection Plot of P16:- A synclinal structure of comparatively high-resistivity is observed to have its low-resistivity trough centred on P16-3, P16-6, and P16-13.

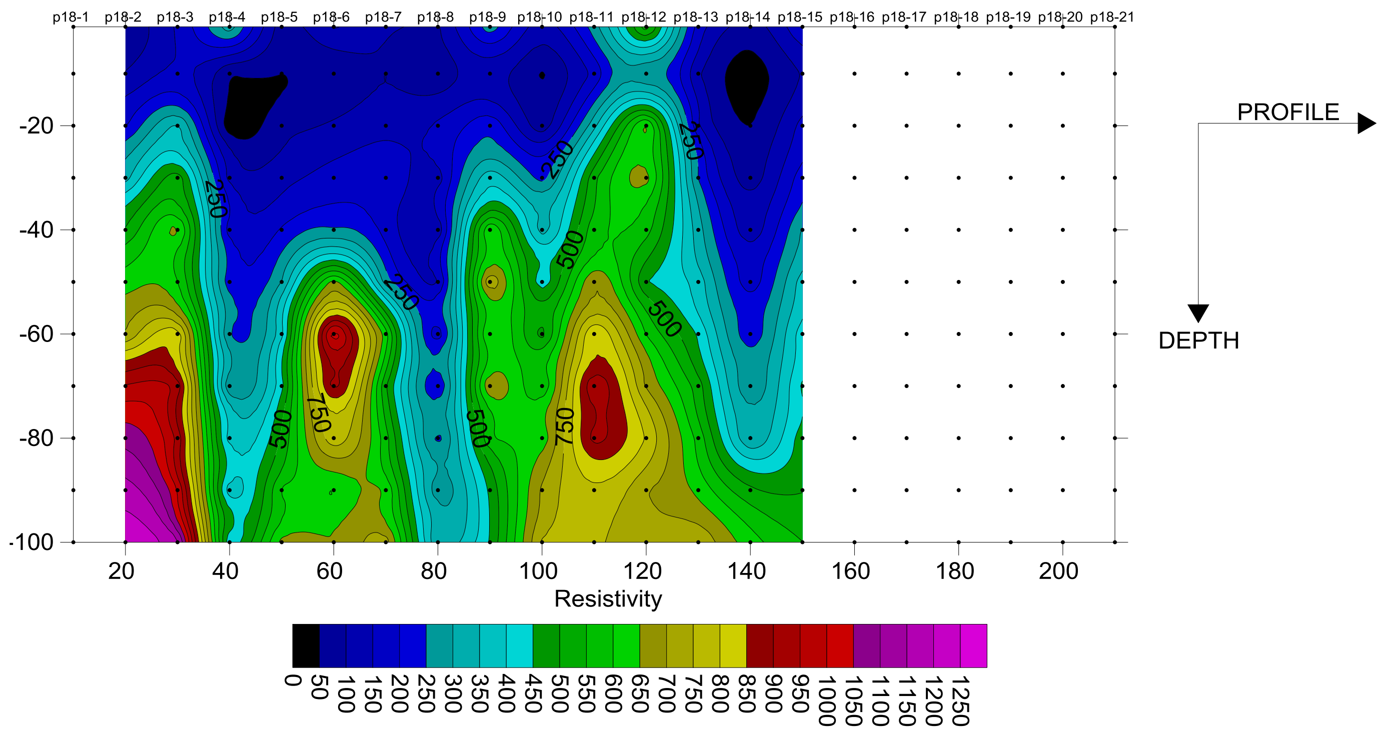

Fig.6. Pseudosection plot for P18

The Pseudosection Plot of P18:- A synclinal structure of comparatively high-resistivity is observed to have its low-resistivity trough centred on P18-4, P18-8, P18-10, and P18-14.

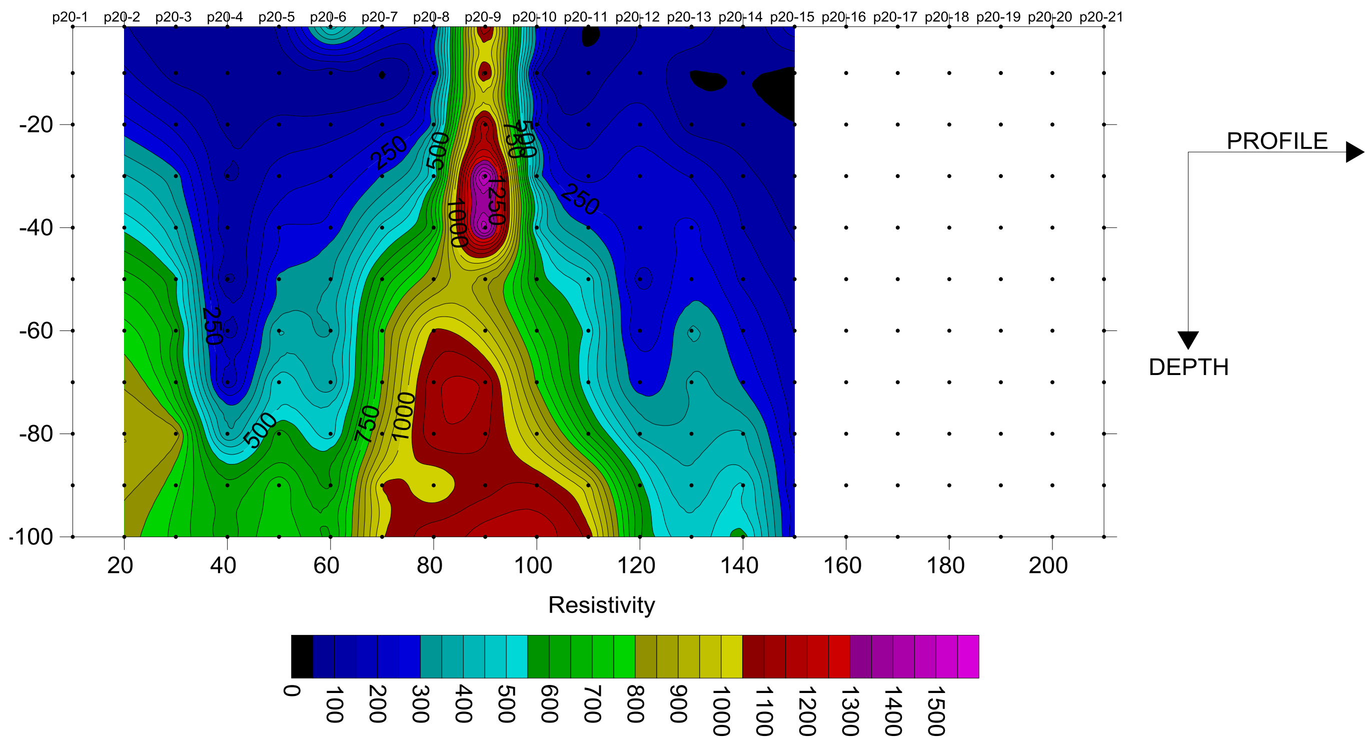

Fig.7. Pseudosection plot for P20

The Pseudosection Plot of P20:- A synclinal high-resistivity material of fractured basement character is observed to have its low-resistivity trough centred on P20-4 and P20-12 plus a deep-seated intrusion at P20-15.

. Aquifer Prospect Designation Based on Observable Subsurface Structural Pattern from the Pseudosection Plots

Along the First North-South Profile (P1):-

P1-11 ($09^0 31'30.18''$; $006^0 25'42.24''$)

Along the Fourth North-South Profile (P4):-

P4-2 ($09^0 31'01.04''$; $006^0 25'48.72''$)

P4-5 ($09^0 31'10.76''$; $006^0 25'48.72''$)

P4-9 ($09^0 31'23.72''$; $006^0 25'48.72''$)

P4-12 ($09^0 31'33.42''$; $006^0 25'48.72''$)

P4-13 ($09^0 31'36.66''$; $006^0 25'48.72''$)

Along the Fourteenth North-South Profile (P14):-

P14-5 ($09^0 31'10.76''$; $006^0 26'21.12''$)

P14-8 ($09^0 31'20.48''$; $006^0 26'21.12''$)

P14-10 ($09^0 31'26.96''$; $006^0 26'21.12''$)

Along the Sixteenth North-South Profile (P16):-

P16-3 ($09^0 31'04.28''$; $006^0 26'27.60''$)

P16-6 ($09^0 31'14.00''$; $006^0 26'27.60''$)

P16-13 ($09^0 31'36.66''$; $006^0 26'27.60''$)

Along the Eighteenth North-South Profile (P18):-

P18-4 ($09^0 31'07.52''$; $006^0 26'34.08''$)

P18-8 ($09^0 31'20.48''$; $006^0 26'34.08''$)

P18-10 ($09^0 31'26.96''$; $006^0 26'34.08''$)

P18-14 ($09^0 31'39.90''$; $006^0 26'34.08''$)

Along the Twentieth North-South Profile (P20):-

P20-4 ($09^0 31'07.52''$; $006^0 26'40.56''$)

P20-12 ($09^0 31'33.42''$; $006^0 26'40.56''$)

P20-15 ($09^0 31'43.14''$; $006^0 26'40.56''$)

Observation

Along each of the profiles selected for this analysis, the observed resistivity values are usually between 200Ωm and 300Ωm at the 20m depth, but for each of the designated prospect listed above the resistivity value is usually *less than 200Ωm at depths greater than 20m*.

Conclusion

While not a popular approach yet, the empirically-formulated "Geoexplore Empirical Standardization for Minna Area" has been validated by a standard VES data analytical technique.

Recommendation

Where the means to analyse VES data for small-scale surveys by computer software are not readily available, recourse to the "Geoexplore Empirical Standardization for Minna Area" should be adopted when working in a Basement Complex province.

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