INVESTIGATION OF LOW-RESISTIVITY REGIMES OF THE SOUTH-CENTRAL PORTION OF GIDAN KWANO (PHASE II), FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

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Abstract
A chiefly standardised, set-piece, and academic approach was used to interpret the result of a 4km² vertical electrical sounding survey at the New Development Phase II, Gidan Kwano Campus, Federal University of Technology, Minna, Nigeria. The constraints imposed by this approach restricted the conclusion that was drawn regarding aquifer prospect to a segment of the southeast and a couple of points in the mid-plane of the area of study as identified by their georeferenced co-ordinates in the eponymous interpretation of the 4km² vertical electrical sounding survey report. However, the area with the greatest data-density fidelity is the portion characterised by consistently low-resistivity values at depths. An examination of this portion from the perspective of the "Geoexplore Empirical Standardisation for Minna Area" makes it clear that it was possible to observe such very low resistivity values at depths of 40m through 70mbecause fracturing of the original fresh basement rock owing to some disturbance in the past would have allowed accumulation of groundwater in the resulting fractures of the buried rock-mass. This observation liberalises the constraint placed on the advisory that it is inappropriate to explore beyond 34m in the core area of study of this work and other works in the suite.

Keywords: Aquifer; fracturing; basement rock; groundwater

Introduction
This paper follows on the heel, so to say, of the eponymous interpretationof a 4km² vertical electrical sounding (VES) survey report; really, the recommendation of that paper (Jonahand Olasehinde,2017) begets this one.The 4km² survey layout in a grid actually defines a north-south (longitudinal traverse, LT) sense and an east-west (transverse traverse, TT) sense in accordance with a proper two-dimensional (2-D) designation.In that report, it was suggested that the portion of consistently low-resistivity values of the iso-resistivity maps at depths be examined from a vista that deviates from the norm; the norm is the recourse to resistivity values of rock types in the Nigerian Basement Complex (NBC).The 4km² tranche of the Phase II (09°30′57.8″N to 09°32′02.6″N and 006°25′39.0″E to 006°26′43.8″E) that is of interest herein is subsumed in the wider 8 km²Phase II (09°30′57.8″N to 09°33′07.4″Nand 006°25′39.0″E to 006°26′43.8″E); this 8 km²swath of land is ideal for the University's near-term and mid-term facility expansion programmes (Jonah *et al.*, 2015A,2015C, 2015D, 2015E; Jonah and Olasehinde, 2015B; Jonahand Jimoh, 2016A; Jonahand Saidu, 2016B; Jonah, 2016C; Jonah and Olasehinde, 2017A; Jonah and Adamu 2017B; Jonah *et al.*, 2018A; Jonah *et al.*, 2018B). On the ground, this 8km² areal extent is a perfect rectangle as seen in Figure 1.

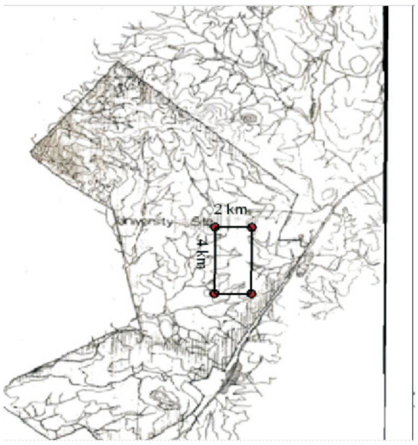

Fig.1. Location most suited for Phase II development at the Gidan Kwano Campus

The portion of current interest is where data-density fidelity is high and where seasonal streams criss-cross the area of study, from Profile 1 Station 1 (P1-1) to Profile 10 Station 1 (P10-1) through Profile 1 Station 17 (P1-17) to Profile 10 Station 17 (P10-17). It is understood from Jonah and Olasehinde (2017A) that "*the station-designation format for this study 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*." The "P1-1 to P10-1 through P1-17 to P10-17" portion of interest of this study is shown colour-coded, against the backdrop of the 2km by 2 km grid, in Figure 2.

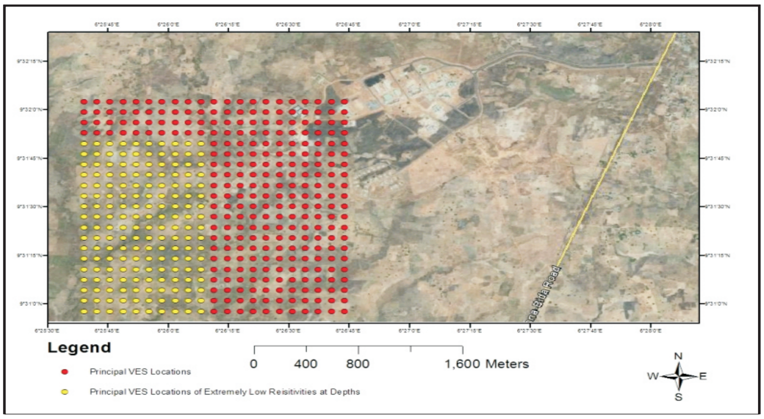

Fig.2: Location ofP1-1 to P10-1 through P1-17 to P10-17

Jonah *et al*. (2015C) reported that the desire of the management of the Federal University of Technology (F.U.T.), Minna, to inaugurate the structural development of Phase II of the Gidan Kwano Campus presented a challenge for the F.U.T. as to the creation of a database that the F.U.T. could consult and incorporate into the wider Physical Planning and Development (PPD) scheme. The authors pointed out that the objective of this study was the creation of a database for aquifer and geotechnical information. Station-separation for this 2km^2 areal extent of the study area was fixed at 200m; thus there were sixty-six principal stations slated for this survey. Further, the authors remarked that, because of the need to ensure independent verification of the results being presented, georeferencing of all survey stations for the vertical electrical sounding (VES) investigation was carried out too. However, only sixty-four principal stations were occupied for this exercise because locations of transverse traverse 11-2 and 11-4 (TT11-2 and TT11-4) were coincident with the top of large outcrops. The authors reported that the data collected was processed by means of the windows-compatible Win Resist® tool to determine the number of layers at each VES station and the Surfer 10 tool to produce the iso-resistivity maps at depths and the map of the thickness regime that is always desired for geotechnical interpretation. The authors clarified that, as a result of invoking the "Geoexplore Empirical Standardisation for Minna Area" (now, formally referenced as Jonah and Jimoh 2016A)and using the depth map as a strict control the VES locations identified as TT1-3, TT1-4, TT2-4, TT4-1, and TT4-3 were flagged as "strongly aquiferous." It was understood that the region of all TT9s, TT10s, and TT11s, incidentally closest to the existing Phase I development, especially TT9-3, TT9-4, TT10-3 were most suited for locations that would not prove logistical challenges for site selection for buildings and other structural development. The authors recommended that the result of this study be adopted wholeheartedly by the Management of the Federal University of Technology, Minna, as a complementary document for the development of Phase II of the Gidan Kwano Campus.

Jonah *et al*. (2015D) concerns the evaluation of geomorphological quality control of geoelectrical data at the Gidan Kwano Campus Phase II Development. The authors pointed out that as part of a suite of protocols needed as controls for geoelectrical data collected out in the field, a purpose-specific topographic map was created to serve as a veritable tool of quality control (QC) for an ongoing fieldwork. It is understood that the three spatial co-ordinate values (x,y,z) that specified full-body georeferencing scheme were collected for 861 principal stations for an 8km^2 grid corresponding to station-spacing of 100m. The authors reported that processing the data set by means of the Surfer®10 route yielded the desired contour map and the corresponding landform profile. As a fine-tuning technique, the authors juxtaposed the landform profile map with acquired geoelectrical field data and they observed correlation that ensures that the field data can indeed be relied upon.

The work of Jonah *et al.* (2015E) was a validation of Jonah *et al.* (2015C) at the Gidan Kwano Campus Phase II Development whence a dual VES-IP approach was employed to plug the knowledge gaps of geological information for the intervening 200m-spread station spacing of Jonah *et al.* **(**2014I**).** Because of the dual VES-IP nature of this survey, the areal extent of this study was limited to 1km^2 and survey proceeded in the transverse traverse (that is, TT) sense. The results obtained indicated that the following VES locations were considered good prospects for groundwater: TT1-2, TT1-3, TT1-4, TT1-6, TT2-1, TT2-2, TT2-3, TT2-4, TT3-1, TT3-2, TT3-3, TT3-4, TT3-5, TT4-1, TT4-2, TT4-3, TT4-4, TT4-5, TT5-1 TT5-2, TT5-4, TT5-5, TT6-5, and TT6-6. The IP data set was used in a qualitative sense for this survey to constrain the conclusion drawn regarding the most promising VES locations of TT5-4, TT1-2, TT1-3, and TT2-2.

Survey Method

The Schlumberger array of the VES mode, at 100m station-spacing, was employed for the survey. The survey trend was an east-west sense for individual stations and a south-north profile. The profile of the acquired data field across the 2km by 2km areal extent needed for this paper is as shown in Figure 2. The methodology of this work exactly mirrors that of Jonah and Olasehinde (2017A) and recourse is made to the results got from that work whence iso-resistivity maps were produced at depths of 10 m through to the 100 m mark at intervals of 10m.

Discussion

Only iso-resistivity maps at depths of 40m, 50m, 60m, and 70m, seen as Figures 3 to 6, would be considered for discussion herein. The rationale for this restriction has been enunciated in Jonah and Olasehinde (2017A): "*The 4km^2 area of study under consideration here (Phase II) is adjunct to Phase I where information on lithology and depths to the fresh basement rock are readily available from six wells drilled as part of the Petroleum Trust Fund (PTF)-sponsored projects (Jimoh, 1998). In the drilling-for-water report of Jimoh (1998), the well around the School of Environmental Technology (S.E.T.) encountered the basement at about 31m. The well around the old Students' Centre (now the School of Entrepreneurship and Management Technology) encountered the basement at 34m, while the well around the Students' Hostel indicated a depth of 37m to the basement. Furthermore, the wells drilled around the Staff Quarters, the Senate Building, and Library Complex encountered the basement at depths of 37m, 34m, and 31m. Thus, it means that the six boreholes encountered the fresh basement at an average depth of 34m. Geological information from Jimoh (1998) indicates that a depth range of 31-34m is beyond the water-bearing zones characterised by weathered and fractured basement rocks. Thus, as the search for water goes, it is inappropriate to explore beyond 34m in the core area of study and in the outlying vicinity.*"

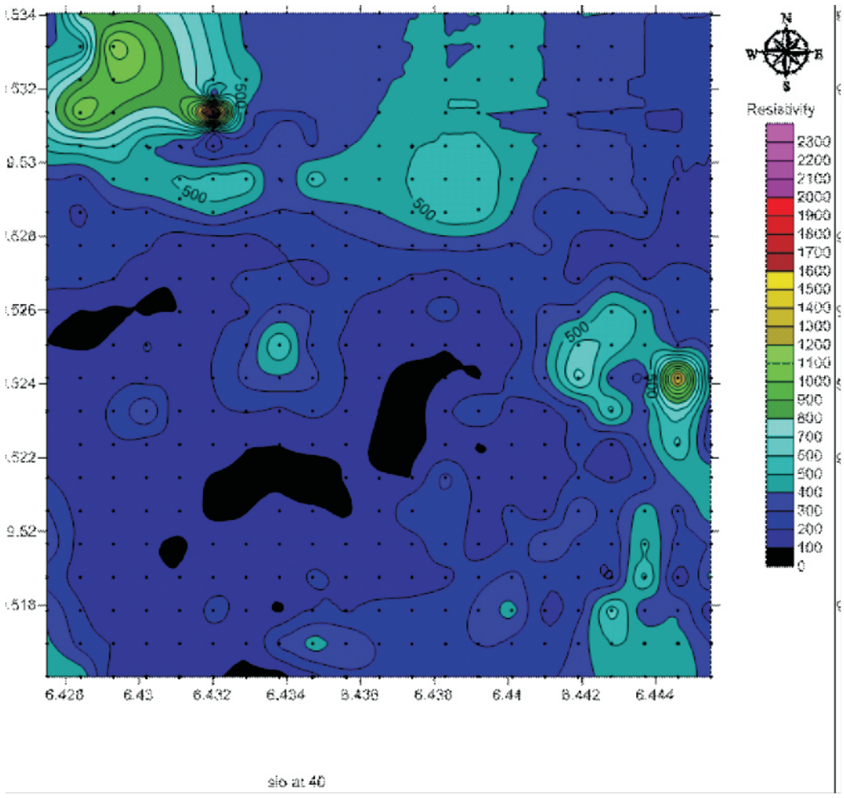

Fig.3. Iso-resistivity map at 40m

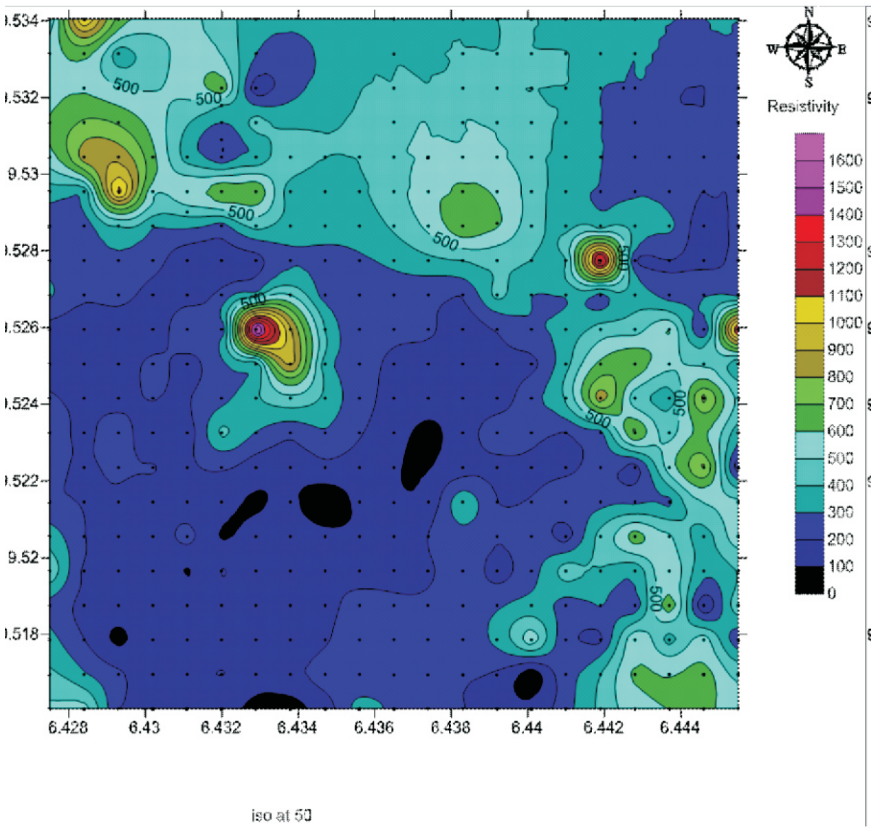

Fig.4. Iso-resistivity map at 50m

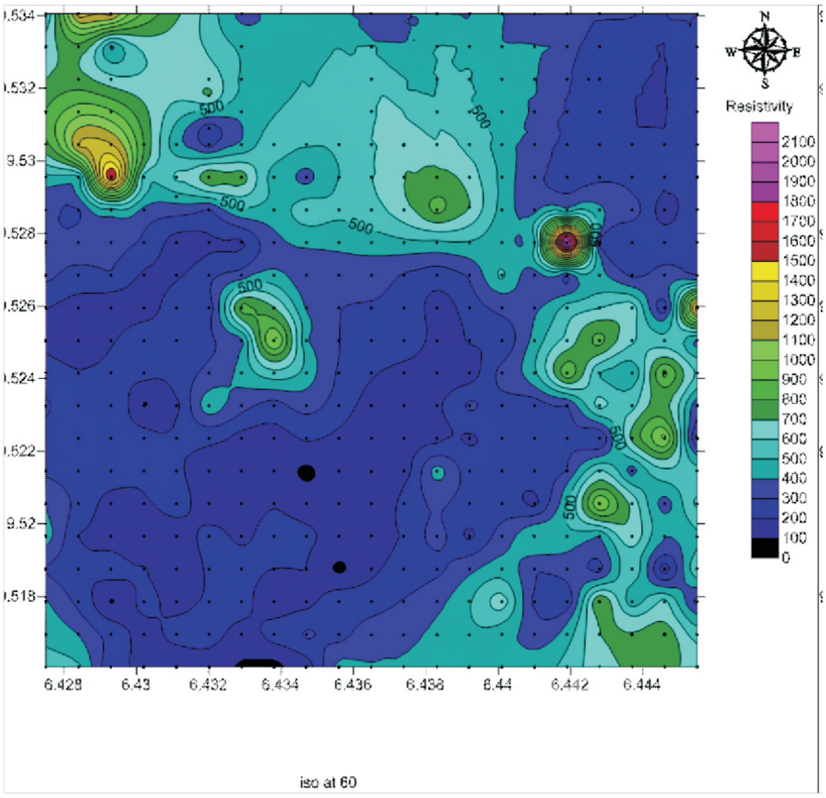

Fig.5. Iso-resistivity map at 60m

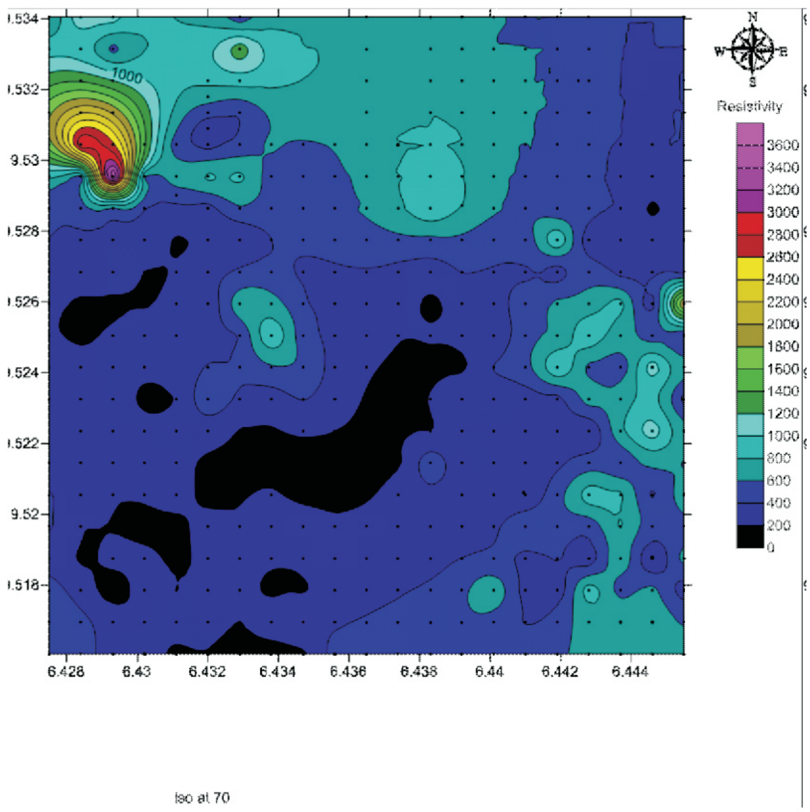

Fig.6.Iso-resistivity map at 70m

In Figures 3 to 6, the portion of current interest where data-density fidelity is high and where seasonal streams criss-cross the area of study (observation from field trips), P1-1 to P10-1 through P1-17 to P10-17, is the two-third southwesternsegment of these figures. An examination of this portion "from a different perspective" entailed seeking the "geological gut feelings" of the progenitor of the "Geoexplore Empirical Standardisation for Minna Area" as to the appropriateness of the following statement quoted earlier: "*Thus, as the search for water goes, it is inappropriate to explore beyond 34m in the core area of study and in the outlying vicinity.*"Knowing that the workers involved in the Jonah and Olasehinde (2017A) survey followed the correct field survey procedures, the protagonist of the aforementioned geological maximventured that it was possible to observe such very low resistivity values at depths of 40m through 70m, over such an areal spread, because "fracturing of the original fresh basement rock owing to some disturbance in in the past would have allowed accumulation of groundwater in the resulting fractures of the buried rock-mass." Actually, an interesting clarification of the subsurface situation at even greater depths can be made out if the iso-resistivity maps at the 80m, 90m, and 100m depth-marks are considered; these are shown as Figures 7 to 9. Examination of Figures 6, 7, and 8 reveal that the existence of the swath of this low-resistivity body beyond the 40m depth-mark is a given and it appears as though this low-resistivity region has been "pinched-out" toward the southwest. This low-resistivity region at 100m clearly implies a deeply-incised fracture system within the basement rock of the area of study.Interestingly, the landform of the area of study actually slopes toward the southwest; this can be made out in Fig. 10, which is the geomorphic feature map created for the wider 8km^2 Phase II.

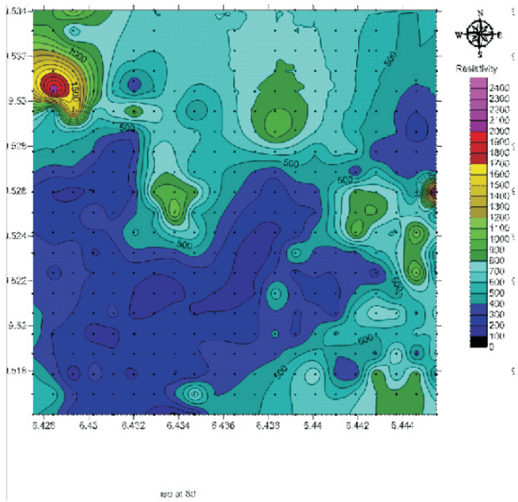

Fig.7.Iso-resistivity map at 80m

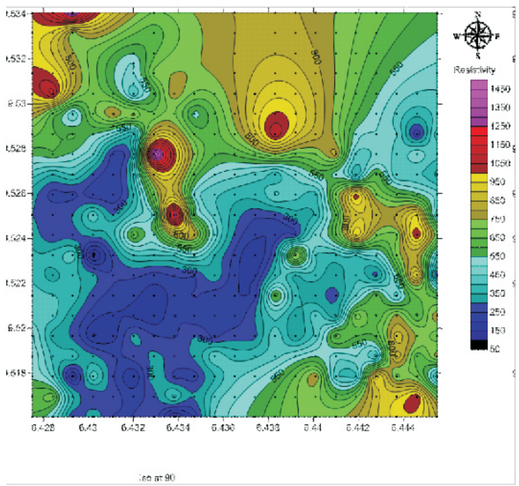

Fig.8.Iso-resistivity map at 90m

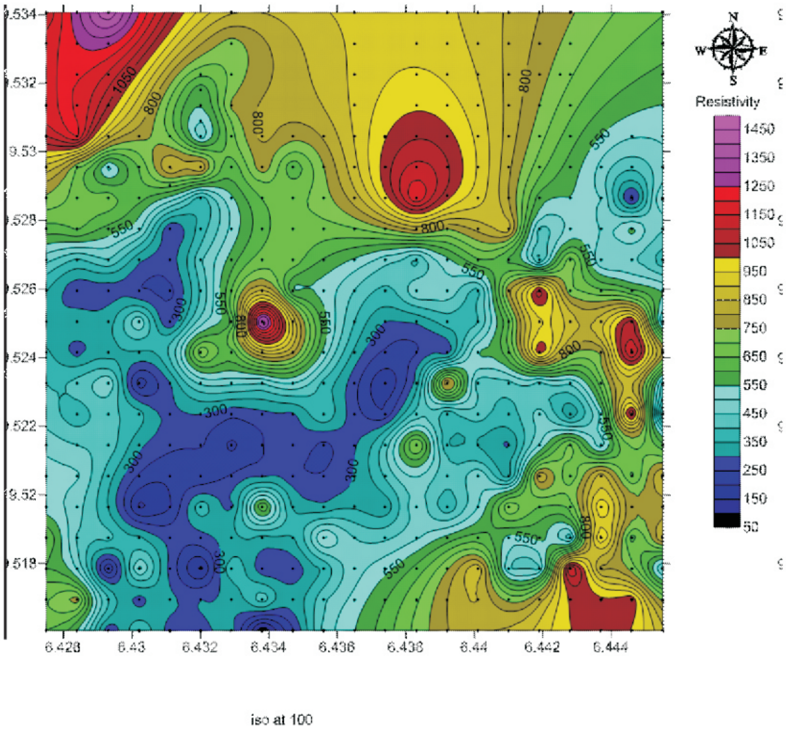

Fig.9: Iso-resistivity map at 100m

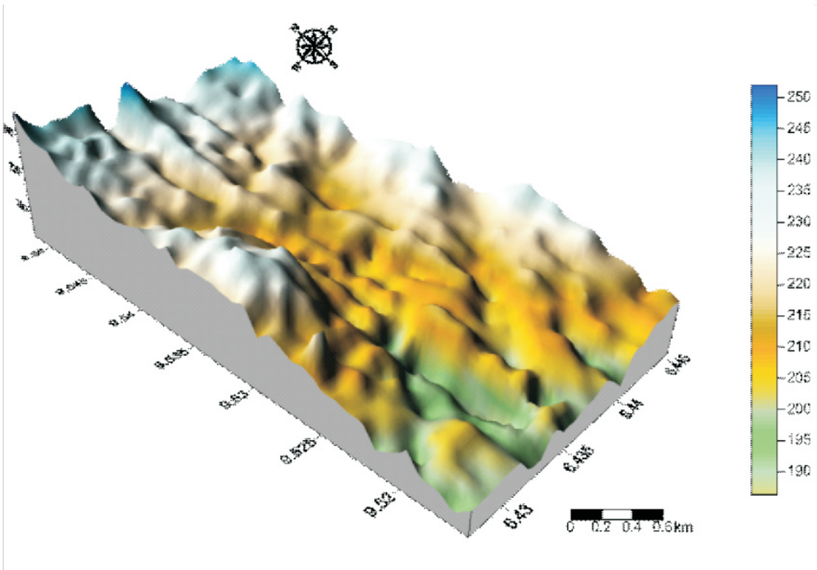

Fig.10:Geomorphic feature map of area of study show that landform slopes toward the southwest

Conclusion

It is known that the areal spread of P1-1 to P10-1 through P1-17 to P10-17 of the southwestern portion of the area of study is criss-crossed by seasonal streams and occupies the low slope of the geomorphic map of the Phase II created for the wider area of study (Figure 10). With the insight gained thus far, attention should be focused on this southwestern portion by means of which future close-spacing VES survey should be undertaken in this part.

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