Application of electrical geophysical techniques for exploration of groundwater in crystalline rocks, Case study: El Obeid area, North Kordofan State, Sudan

By:

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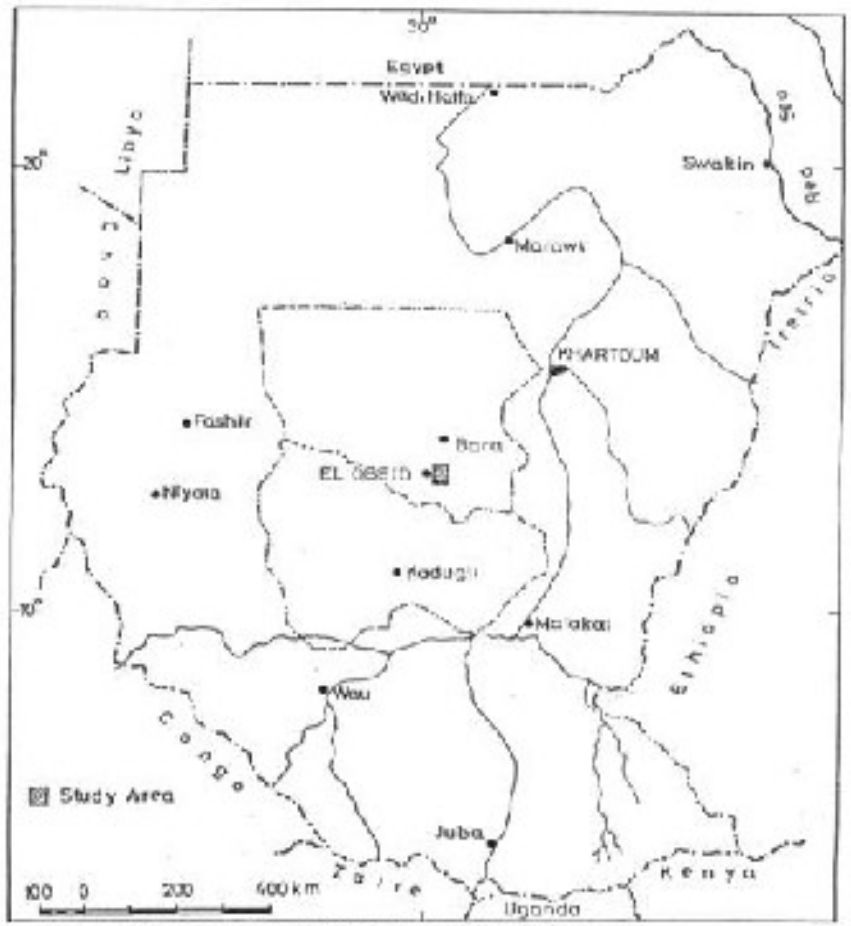
INTRODUCTION

- This paper describes the application of electrical geophysical techniques mainly, electrical resistivity for exploration of groundwater in basement areas.

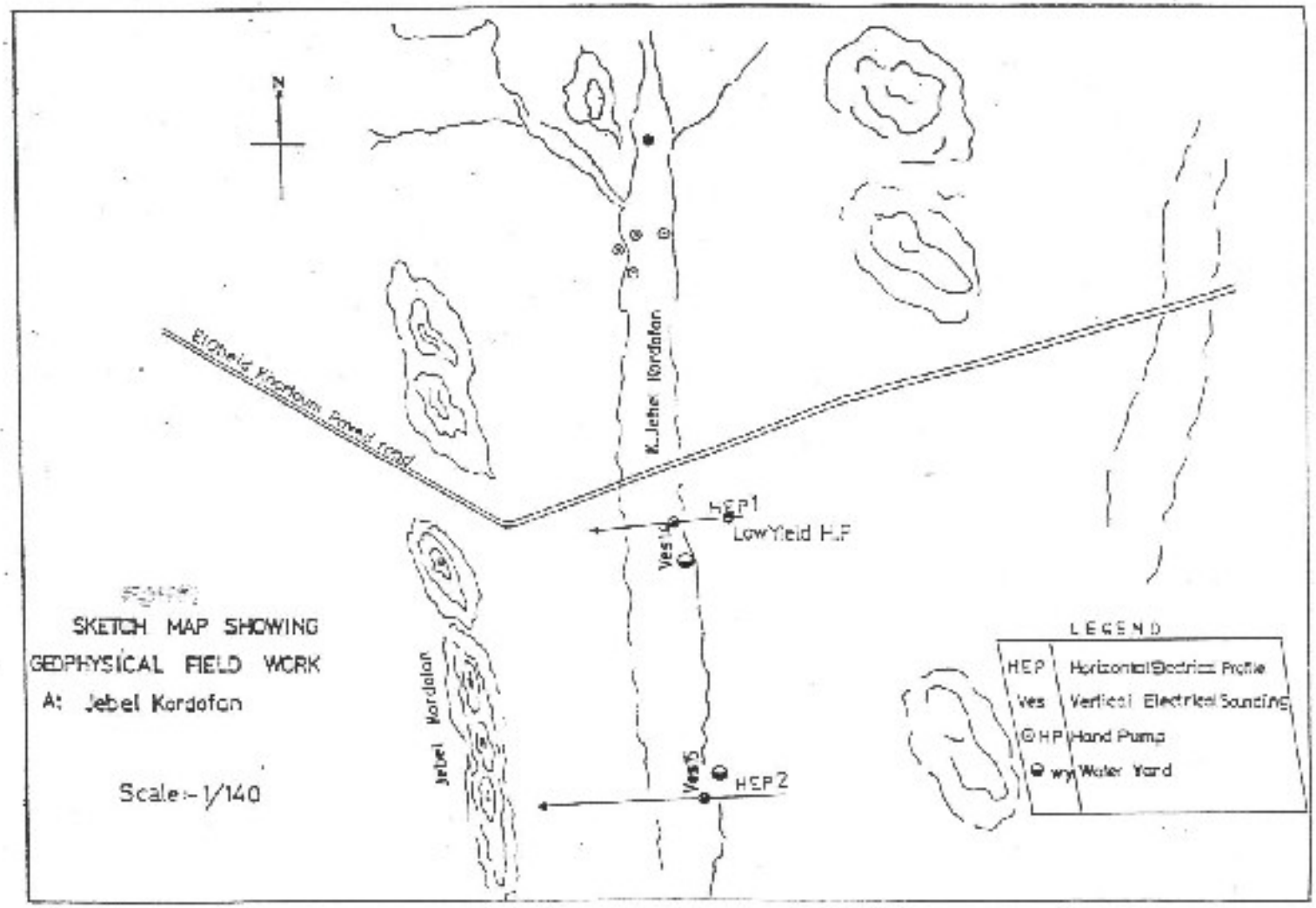
- Geophysical methods are used to obtain more accurate information about subsurface conditions, such as type and depth of materials (consolidated or unconsolidated), depth of weathered or fractured zone, depth to groundwater, depth to bedrock, and salt content of groundwater (Bouwer, 1978)). Magnetic surveys have been used to study basalt aquifers and alluvial basins underlain by magnetic bedrock (Zohdy et al., 1974).

Location, Geology and Hydrogeology :

El Obeid area is largely a plain of low relief, broken occasionally by isolated hills e.g. Jebel Kurbage and J. Kordofan, and some sand dunes are scattered in the area. The altitude of the study area ranges from 520 to 615 above mean sea level (a.m.s.l.) Geologically the area is composed of basement complex rocks (gneisses, metasediments, metagabbro and foliated granites). This beside rhyolite, ignimbrites and Nawa Series rocks (well consolidated micaceous and non micaceous sandstone, shales and mudstones). The Nubian sandstone Formation (composed of conglomerates, mudstone and sandstone) and Um Ruwaba formation (composed of sands clays and gravels) and superficial deposits, were also found. The hydrogeological units recognized in the area comprise the weathered basement aquifer, fissured and cracked basement aquifer, the alluvial aquifer, Nubian Sandstone and Um Ruwaba Formation aquifers beside the superficial deposits aquifer.



Location Map of the Study Area in Sudan


N
El Obeid Khartoum paved road
K. Jebel Kordofan
HEP1
Low Yield H.P
Ves14
Ves15
HEP2
Jebel Kordofan
SKETCH MAP SHOWING
GEOPHYSICAL FIELD WORK
At: Jebel Kordofan
Scale:- 1/140
LEGEND
HEP Horizontal Electrical Profile
Ves Vertical Electrical Sounding
HP Hand Pump
wy Water Yard

METHODOLOGY

- The electrical geophysical method used in this study, was electrical resistivity, and the techniques applied were, horizontal electrical resistivity profiling (HEP), and vertical electrical sounding (VES).
- As shown on Fig (2) and Fig (3a), the horizontal electrical resistivity profile 1 (HEP 1) is 450 m long, trending in east-west direction and lies 200m south Khartoum- El Obeid paved road and Khor Jebel Kordofan bridge. The starting point of the profile measurement (Station No. 1) is being from existing hand pump No. 329 of low yield (numbering according to National Rural Water Corp of North Kordofan State), then the profile directed to the west and continue up to the west side of Khor Jebel Kordofan channel. During the measurements two high resistivity readings were observed at the beginning and the end of the profile. The horizontal electrical resistivity profile 2 (HEP 2) (as shown on Fig 2 and 3b), was conducted two kms south HEP 1, 575m long, running perpendicular across Khor Jebel Kordofan, and trending in east-west direction. It was conducted at Salah A/Gadir garden area irrigated by a water well as shown on Fig 2.

The other electrical resistivity technique used was the vertical electrical sounding (VES), where VES1 and VES2 were carried out with AB/2 (separation between current electrodes) at the center of the electrical resistivity HEP1 and HEP2 respectively (Figs 3a and 3b). VES 1 was carried out at the center of anomaly that shown by station 11 at HEP1. This VES1 is to verify the HEP1 anomaly, to determine the thickness and type of lithological units and to recognize if there is water bearing horizon above the fresh basement rocks. The VES2 (as shown on Fig 2 and 3b) was conducted to confirm the electric resistivity anomaly that shown by HEP2 at station 3.

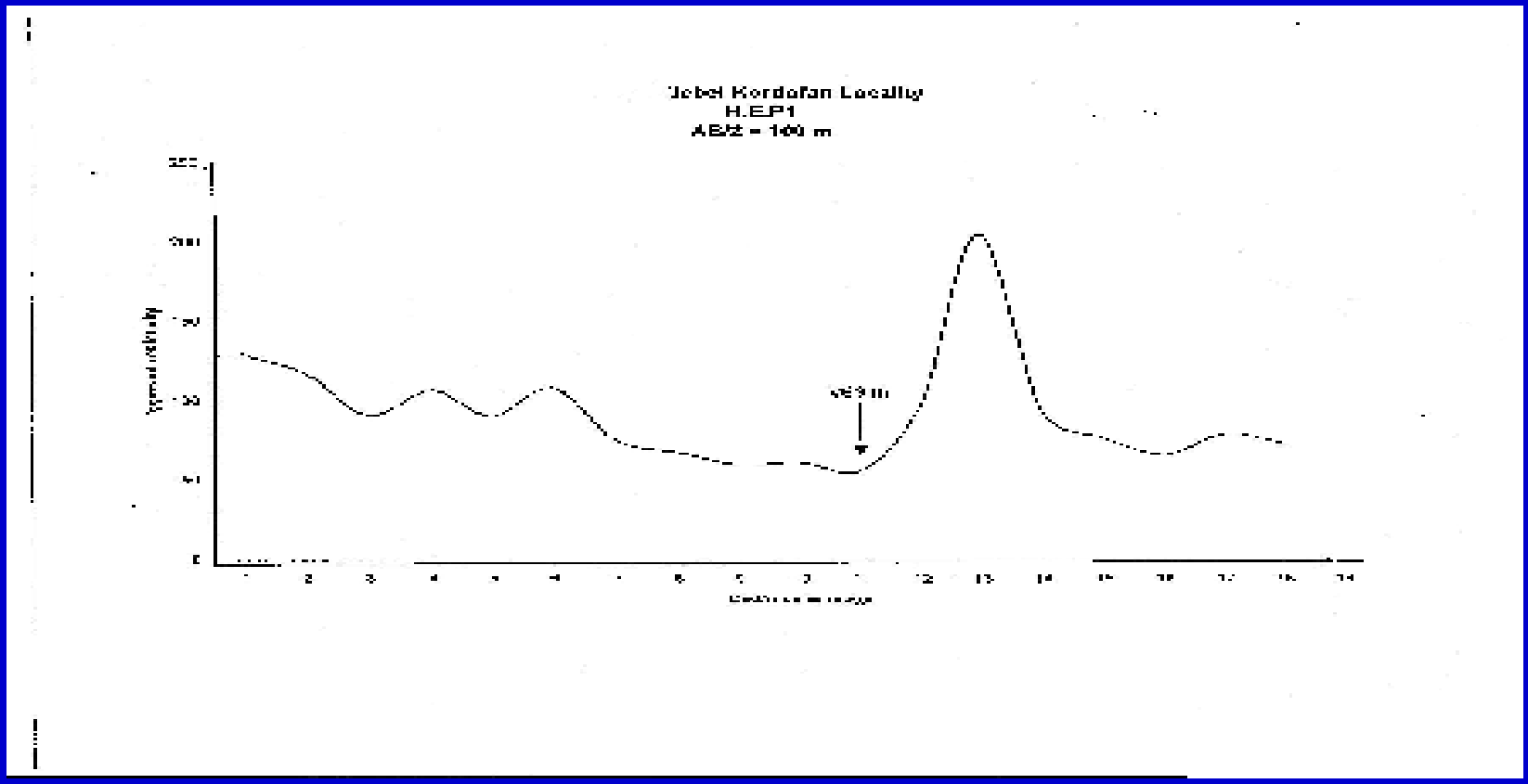


Fig 3a: Showing Horizontal electrical resistivity profile No. 1 (HEP 1)

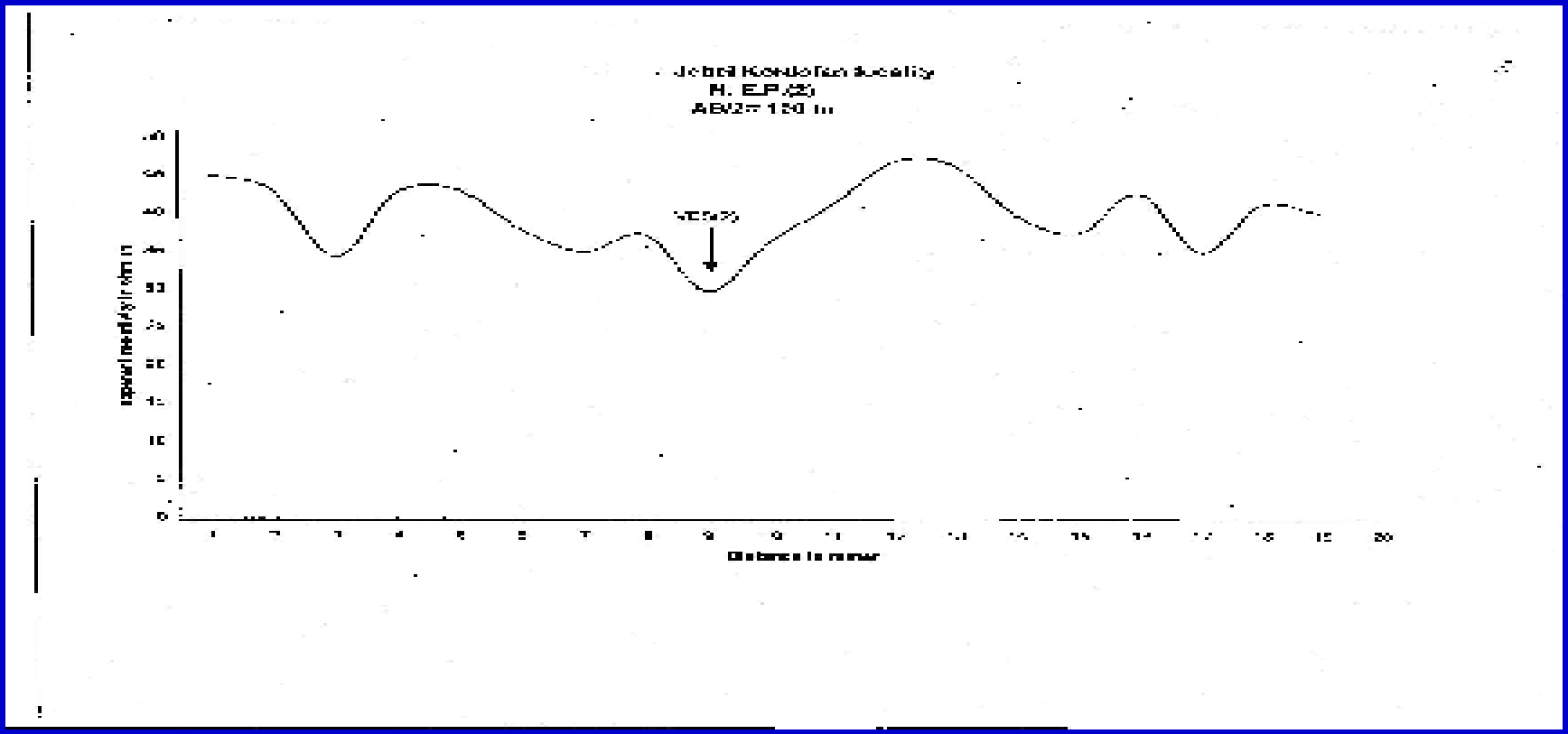


Fig 3b: Showing Horizontal electrical resistivity profile No. 2 (HEP 2)

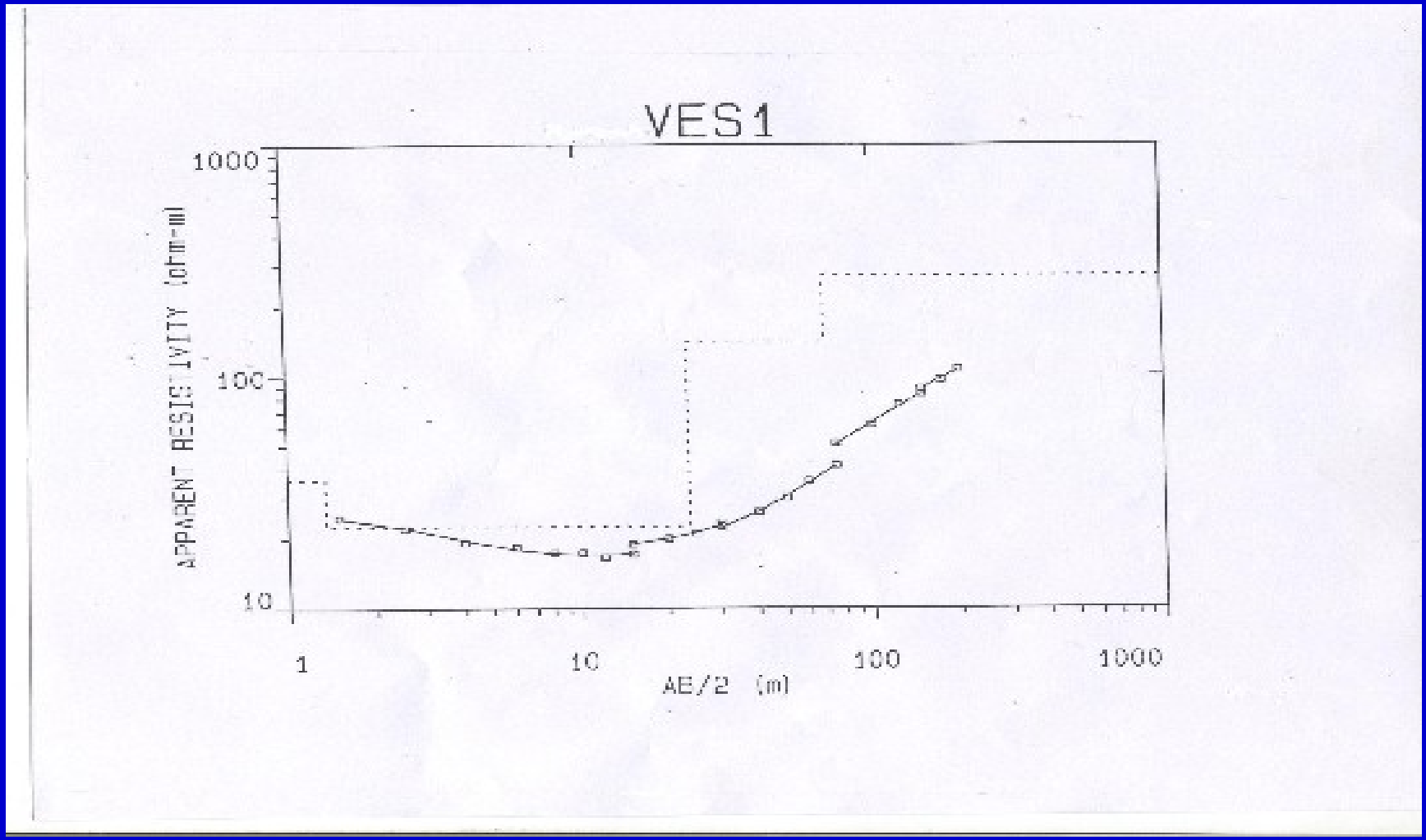


Fig 4a: Showing vertical electrical sounding No. 1 (VES 1)

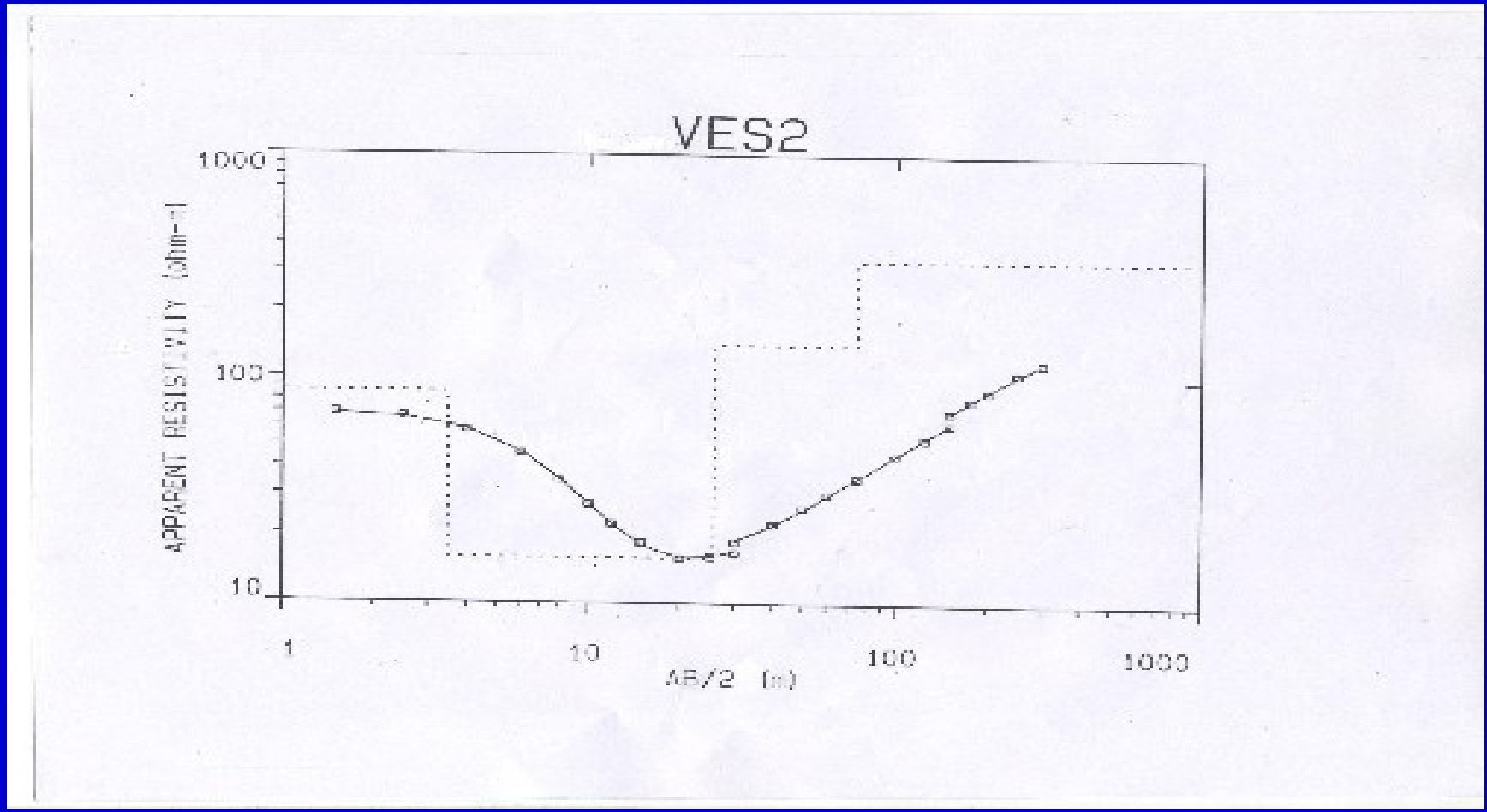


Fig 4b: Showing vertical electrical sounding No. 2 (VES 2)

RESULTS AND DISCUSSION

- The result of the first horizontal electrical resistivity profile (HEP1) showed the followings:
- The anomaly center at station 11 is 275 m away from the start measurement point of the profile, situated out of the Khor channel and confirmed by VES1 (Fig 4a).
- From geological survey in the study area, a quartz dyke was outcropping inside the Khor at station 13 and it is corresponding to an apparent resistivity of 205 ohm-m.
- The present geophysical survey insures that the hand pump No. 329 is not in a suitable hydrogeological site, and hence it has low yield, this because it is located without geophysical investigation.
- The following results were obtained from the application of electric resistivity profile 2 (HEP 2):
- The profile shows two anomalies at station 3 and 9 (Fig 3b). The anomaly at station 3 coincide with the structure of Salah A/Gadir well, and it was examined by vertical electrical sounding 2 (VES2). The other anomaly at station 9 is 50 m west of the Khor channel.
- The thickness of weathered basement complex rocks above the fracture zone in the area of Khor Jebel Kordofan lead to the increasing of the aquifer horizons and discharge in the area.
- The present study confirms that Khor Jebel Kordofan is structurally controlled.

- The present study confirms that Khor Jebel Kordofan is structurally controlled.
- The result of application of VES1 (Fig 4a) probably shows three lithological units of different lithological description, thickness and resistivity value, and of total thickness of about 69 m above the hard or fresh basement rocks. These geological formation may include the superficial deposits of clayey sand. It has a thickness of about 2 m and resistivity 36 ohm-m overlain the weathered basement rocks. The weathered basement rocks has a thickness of about 22 m and resistivity value of 22 ohm-m. The weathered basement rocks with saturated fractures and thickness of 45m and resistivity of 140 ohm-m, situated above the hard or fresh basement rock of resistivity value of about 270 ohm-m.
- The VES2 (Fig 4b) was conducted to confirm the electric resistivity anomaly that shown by HEP 2 at station 3. This VES shows three layers of different lithological units of total depth of about 75 ms above the hard or fresh basement rocks of resistivity of about 338 ohm-m. This geological formation is probably composed of superficial deposits of sand of different grain size and has a thickness of about 22 ms and resistivity value of about 16 ohm-m. The weathered saturated fractured basement complex rocks indicate a thickness of 49 ms and resistivity about 141 ohm-m.

CONCLUSION

- From the discussion of results obtained by the horizontal electrical resistivity profiling and vertical electrical resistivity sounding, together with the geological and hydrogeological investigations in the study area, the following points can be concluded:
- The anomaly center is out of Khor Jebel Kordofan channel, and there is a quartz dyke inside the flooded area of the Khor channel. Also there is a thick weathered basement rock above the fractiured zone and the fresh or hard basement rocks.
- There are three lithological units above the fresh basement rocks with apparent resistivity values ranging from 17 to 81 ohm-m, and with depth ranging from 69 to 75 ms over the fresh basement of resistivity value of 338 ohm-m. The superficial deposits are mainly sand which overlain the weathered basement rock and has a thickness of 1 to 2 ms.
- The study revealed that the area of J. Kordofan is good for accumulation of considerable quantities of groundwater, as it is a basement rock area, this because of the presence of suitable geological structures and recharge zones.
- It can be recommended that, although the area of Jebel Kordofan is a basement rock area, is suitable for drilling groundwater bore holes and production of groundwater used for different purposes.

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