ISSN......... 0189-9546
Faculty of Engineering & Technology, University of Ilorin, Ilorin, Nigeria.

GEO-ELECTRICAL EXPLORATION FOR GROUNDWATER WITHIN THE PREMISES OF UNIVERSITY OF ILORIN TEACHING HOSPITAL, ILORIN, KWARA STATE, NIGERIA

A. K. OLAWUYI
Department of Geology, University of Ilorin, Ilorin, Nigeria
gideonola2001@yahoo.com

Received: 26 May 2012 *Revised: 07 December 2012*
Accepted: 14 December 2012 *Published: 19 December 2012*

ABSTRACT

Schlumberger Vertical Electrical Soundings for groundwater search within the premises of University of Ilorin Teaching Hospital(UITH) situated along Ilorin-Jebba road in Kwara state, were carried out with a view to establishing the different subsurface geoelectric layers, the aquifer units and their hydrogeologic properties. Data were collected from 12 VES stations over an area of about 500m x 650m. From the quantitative interpretation of the data collected, using the usual method of curve matching with the Orellana-Mooney Master curves and 1-D forward modeling with WinResist 1.0 version software, four lithologic units were identified. These include: the topsoil, the lateritic layer, the weathered layer/fractured layer and the fresh basement. The weathered and fractured basement constitutes the main aquifer units. The 2-D resistivity structure has elicited 2 lobes of low resistivity which constitutes the prospective zone for water in the area. The first lobe exists below stations 3 and 4 at about 5-15 m depth, with resistivity between 80- 147 ohm-m and over 300m wide, while the other lobe of low resistivity which also signifies a possible borehole location exists below stations 7, 8 and 9 at a depth of about 2-14 m, with resistivity between 141-200 ohm-m and over 550 m wide. The study concluded that the area investigated contains two lobes of low resistivity which could be explored for water supply.
Key words: Aquifer, Lobe, Resistivity, lithology, geo-electric, borehole.

1. INTRODUCTION

Geophysical study of the permanent site of the University of Ilorin Teaching Hospital, Ilorin East Local government Area of Kwara State, Nigeria (Figure 1) was carried out. The paper describes the results of geophysical study using direct current (d.c.) resistivity methods. The goals of this study are:

(i) To avert a case of borehole abandonment usually necessitated by quartzite encountered at shallow depth.

(ii) To have a more detailed understanding of the hydrogeology of this area and delineate zones that are favourable for borehole locations.

The study area is underlain by precambrian rocks of the Nigerian basement complex in which groundwater occurs either in the weathered mantle or in the joint and fracture systems in the un-weathered rocks (Vandeberghe, 1982; Ako and Olorunfemi, 1989 and Olayinka and Olorunfemi, 1992). Groundwater in Nigeria is restricted by the fact that more than half of the country is underlain by crystalline basement rock of pre-cambrian era (Kazeem, 2007). The highest groundwater yield in the basement terrains is found in areas where thick overburden overlies fractured zones (Olorunfemi and Fasuyi, 1993). These zones are often characterized by relatively low resistivity.

In view of the discontinuous (localized) nature of basement aquifers, drilling programmes for groundwater development should generally be preceded by detailed hydro-geophysical investigations (Omosuyi *et al.*, 2008). The geophysical exploration method, especially the Vertical

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Electrical Sounding (VES) has continued to play a leading role in the exploitation of groundwater in Nigeria (Van Overmeeren, 1989). In this study, the VES technique was used to delineate the different subsurface geo-electric layers, the aquifer units and their hydrogeologic properties.

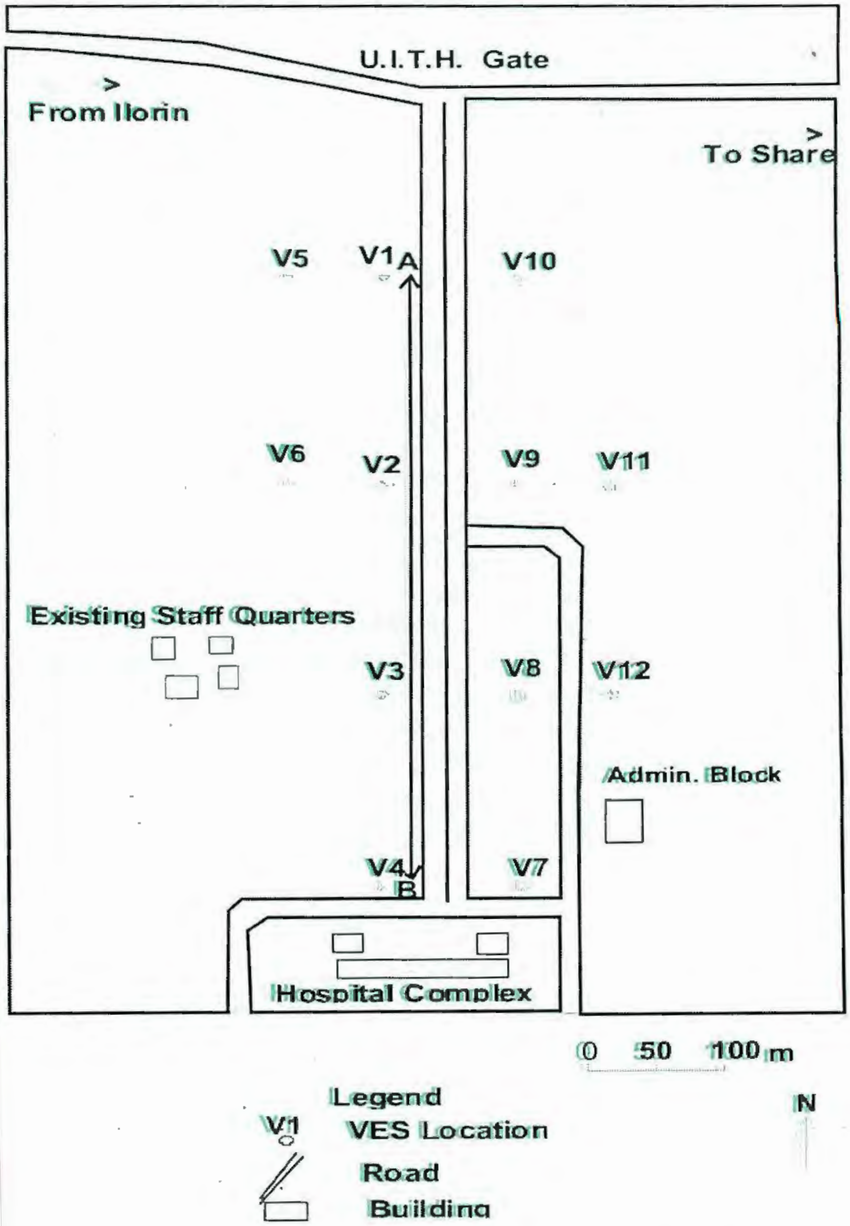

Figure 1: Sketch Map of the Study Area showing VES Positions.

2. MATERIALS AND METHODS

2.1 Geology

Geological map showing Ilorin, the study area is shown in Figure 2. The area under study falls within the basement complex of Nigeria. Oyawoye (1972) classified the basement complex into four main rock groups using lithology. These include; (i) the older granites (ii) the migmatite complex (iii) the metasedimentary series and (iv) Miscellaneous rock types. A good representation of these rocks could be present in the subsurface but are covered by the lateritic and weathered overburden, except a few occasional exposures of hard rocks as boulders on the study area.

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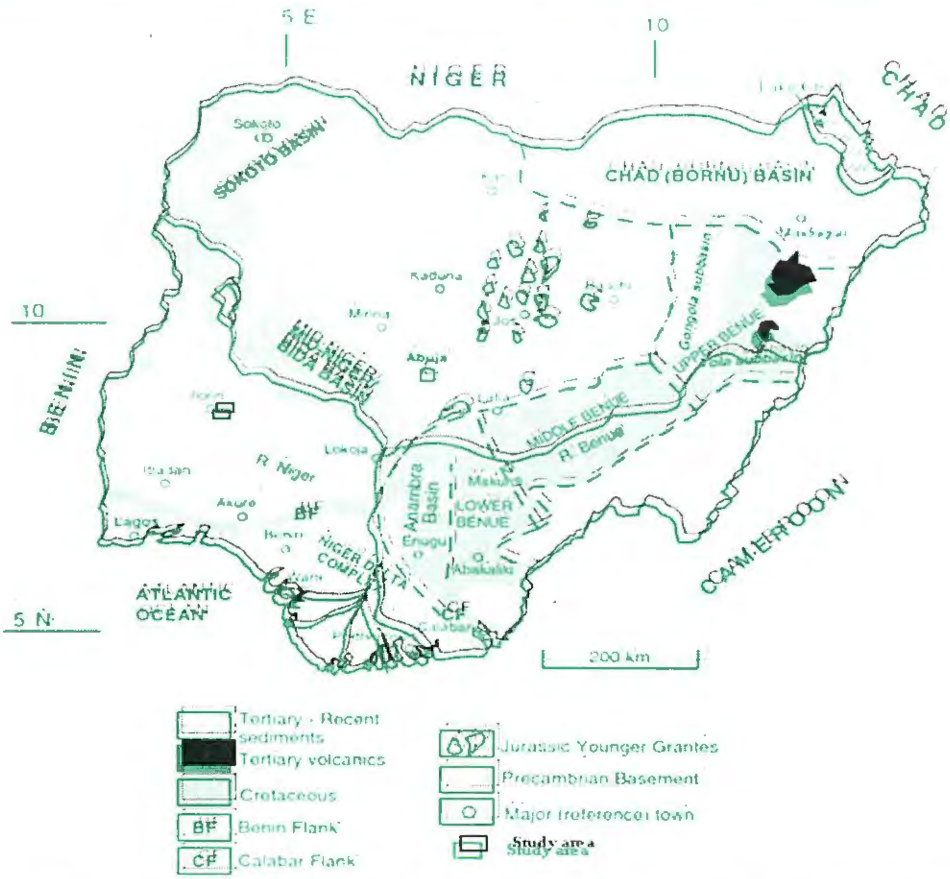

Fig. 2: Geological sketch map of Nigeria showing the major geological components (Basement, Younger Granites and Sedimentary Basins) and the study area (After Obaje, 2012)

2.2 Principle and Method

Electrical resistivity survey is usually designed to measure the electrical resistivity variation of the subsurface materials by making measurements at the earth surface. The common electrode arrays suitable for VES work are the Wenner and the Schlumberger arrays. In the Schlumberger array the spacing between the potential electrodes must not exceed 40% of half the distance between the current electrodes (Adewumi et al., 2005).

Apparent resistivity for the schlumberger array (Pa) is computed from the equation below

Pa = $\frac{nL^2}{I}\frac{\Delta v}{(2l)}$ (Sharma, 1997)

where (2L) is the distance between the current electrodes (AB), (2l) is the distance between the potential electrodes (MN), $\frac{\Delta v}{2l}$ is the surface gradient of potential at the midpoint between M and N, and I is the input current.

Twelve vertical electrical soundings (VES) were conducted in the study area (Fig.1). The profiles were run on the undeveloped part of the area. The current was sent into the ground through the outer electrodes. The potential difference derived from the current obtained from 12V (d.c.) battery was measured using a voltmeter. The apparent resistivity values were calculated by multiplying the resistance value obtained at the point with the geometric factor. For the vertical electrical soundings, the maximum spread of the current electrodes (AB/2) was one hundred metres which is adequate for good penetration into the basement rock around this environment. The VES curves were

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quantitatively interpreted by partial curve matching and computer iteration techniques (Sharma. 1997). The partial curve matching technique involved segment by segment matching of the field curves with two layers model curves and their corresponding auxiliary curves. The 2-D resistivity structure was obtained from DIPPRO™ 4.0 inversion software.

3. RESULTS AND DISCUSSIONS

3.1 Geo-Electric Layers and Corresponding Resistivity Values

The VES interpretation results indicated three to five major layers/lithologies: the top soil. the lateritic layer, the weathered layer/ the fractured layer and the fresh basement or bedrock. The topsoil and the lateritic layer are merged in places especially where the two units share identical electrical properties. Typical sounding curves are shown in Fig 3, most of whose geoelectric layers vary from three to five (Reynolds, 1997).

The resistivity values for the topsoil vary from 70 to 750 ohm-m with the highest frequencies in the 70 to 250 ohm-m range. The low resistivity end (<250 ohm-m) is diagnostic of clay / sandy-clay and clayey sand, while the high resistivity end (>250 ohm-m) typifies compacted sand and laterites. The topsoil (1^{st} layer) thickness varies from 0.29 to 1.0 m. This layer is composed of clay, lateritic clay, sandy clay, clayey sand and sand. This accounts for the wide resistivity range (Okhue and Olorunfemi, 1991).

The resistivity values for the second layer vary from 4.36 – 2520.0 ohm-m with the most frequently occurring resistivity values in the 4.36-250.0 ohm-m range. The low resistivity end (<10.0 ohm-m) is typical of clay-sandy clay and clayey sand while the moderate resistivity (10 ohm-m) typifies compacted sand and laterites. The layer thickness varies from 0.03-6.05 m.

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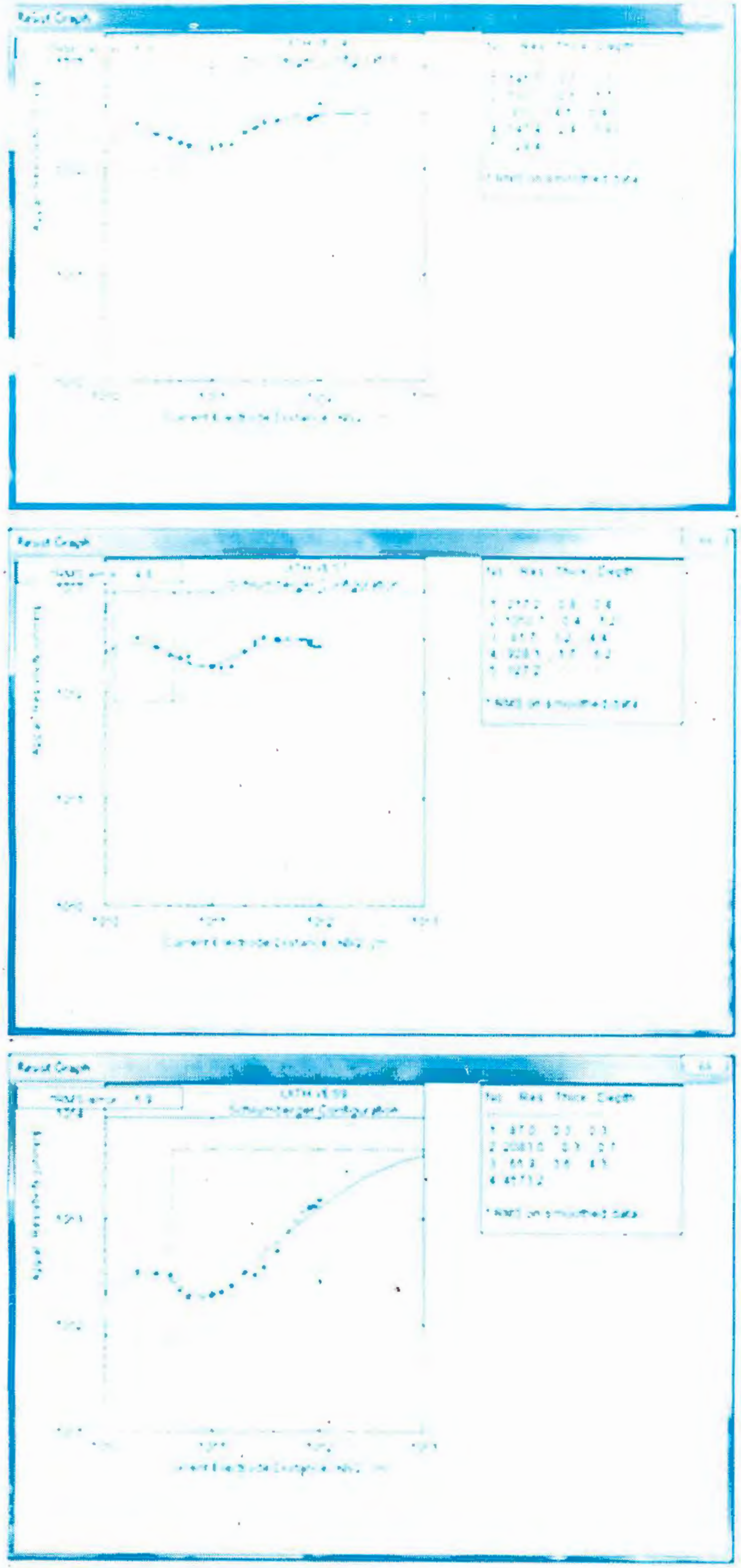

Fig.3: Typical Schlumberger sounding curves obtained in the study area

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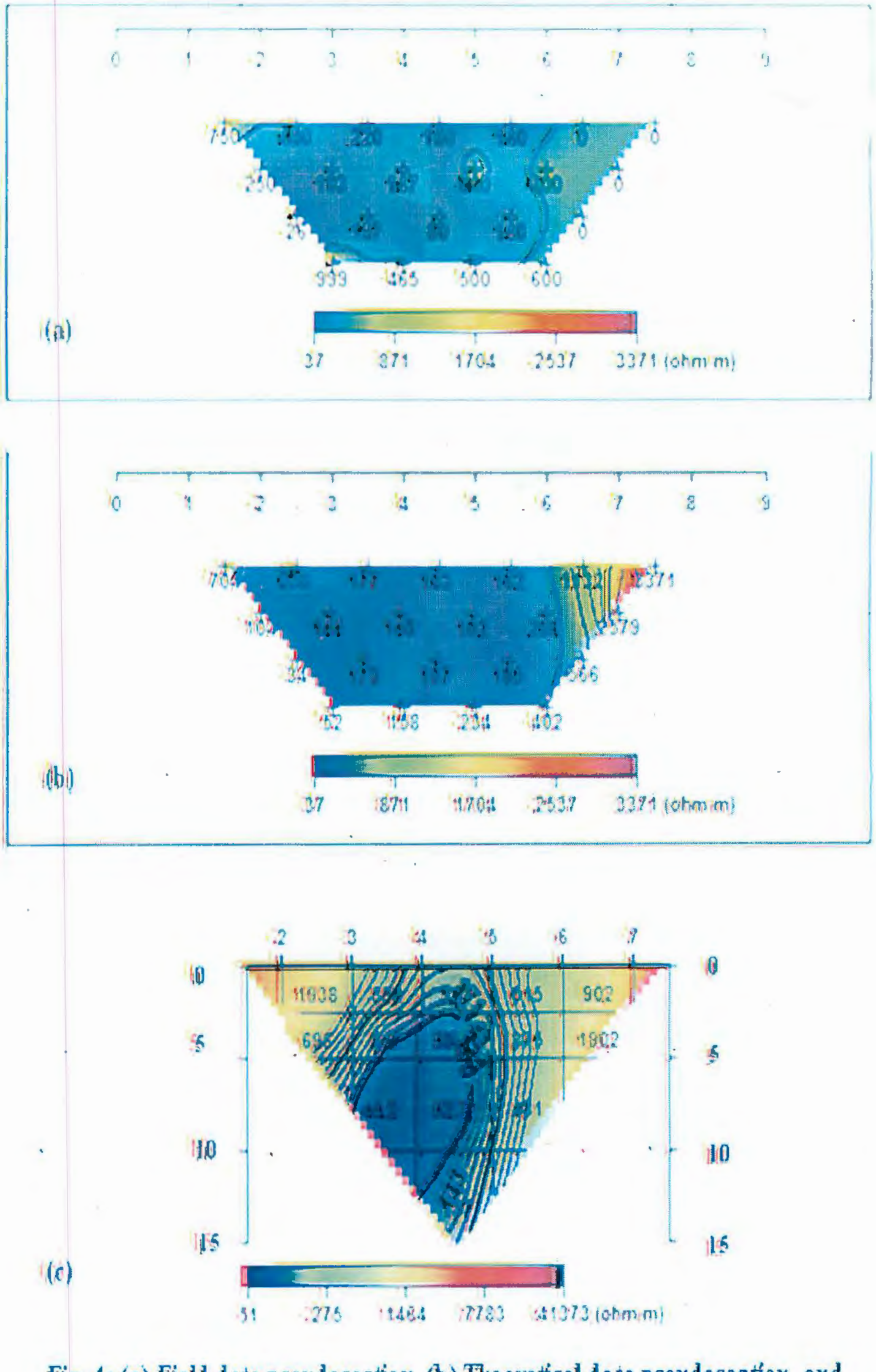

Fig. 4: (a) Field data pseudosection, (b) Theoretical data pseudosection and (c) 2-D resistivity structure along traverse AB.

4. CONCLUSIONS

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The hydro-geophysical investigation of the University of Ilorin Teaching Hospital Permanent Site, Ilorin, Kwara State, Nigeria was carried out with the aim of identifying prospective zones of groundwater accumulation which could be exploited for public consumption and other household/hospital purposes. The geoelectric section has revealed three to five geoelectric units. The horizons include the top soil, the lateritic layer, the weathered layer, the fractured basement and the fresh basement unit. The 2-D resistivity structure revealed that the subsurface lithologies are characterized by lobes with low resistivity which constitutes the prospective zone for water exploration in the area. A prospective zone exists below stations 3 and 4 at about 5- 15 m depth, with resistivity between 80- 147 ohm-m and over 300m wide (Traverse AB, Fig. 4), while the other lobe of low resistivity which also signifies a possible borehole location exists below stations 7, 8 and 9 at a depth of about 2-14 m, with resistivity between 141-200 ohm-m and over 550 m wide. Another which also signifies a prospective borehole zone exists below stations 7, 8 and 9 at a depth of about 2-14 m and over 550 m wide. The weathered and fractured basement constitutes the main aquifer unit in the study area. The 2-D resistivity structure of the overburden shows that depths to the fresh basement vary from 0.5 to 16.6 m in the study area. The study area has been delineated into prospective high and low groundwater potential zones based on geoelectric characteristics. The study concluded that the study area contains two lobes of low resistivity which are prospective zones for water accumulation.

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