OBAFEMI AWOLOWO UNIVERSITY

INTEGRATED GEOPHYSICAL AND GIS-REMOTE SENSING INVESTIGATIONS FOR GEOLOGICAL AND GROUNDWATER MAPPING IN THE NORTH-EASTERN PART OF OSUN STATE, NIGERIA

BY

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CERTIFICATION

This research wascarried out by OLAJUYIGBE,Oluwaseyi Emmanuel(SCP13/14/H/0869)in the Department of Geology, Faculty of Science, ObafemiAwolowo University, Ile-Ife. The thesis has been read and approved as meeting part of the requirements for the award of Master of Science (M.Sc.) Degree in Applied Geophysics. To the best of our knowledge, the thesis has not been presented elsewhere for the award of any degree or publication.

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Dr. D. E. Falebita	**Dr. S. A. Adekola**
Supervisor	**Head of Geology Department**

DEDICATION

This research is dedicated toAlmighty Godfor keeping me alive till this day and for the grace and strength bestowed on me to complete thisthesis and M.Sc. Degree successfully.Also to my parent for their unwavering moral, spiritual and financial support throughout my programme, despite thelimited resourcesat their disposal.

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ABSTRACT

This study mapped the surface and subsurface lineaments associated with the study area,determined their orientations, also determined the geoelectriclayers and their parameters, estimated the overburden thicknesses and evaluated the groundwater potential of the study area. This was with a view to characterize the geological complexities associated with groundwater distribution in the study area.

Geological map, Total Aeromagnetic Intensity (TMI) data and satellite imageries comprising Landsat 8 and Shuttle Radar Topography Mission of the study area, covering about 57 × 47 km^2 (bounded by Longitudes 4°32′33″ - 5°03′28″ E and Latitudes 7°39′58″ - 8°05′43″ N), were acquired from the United States Geological Survey and Nigeria Geological Survey Agency. 1-D Vertical Electrical Sounding (VES) data using the Schlumberger array configurationwere acquired from various sources. The imageries were spatially filtered for extraction of surface lineaments and verified for their hydrogeological significance. The Total Magnetic Intensity (TMI) data was processed to accentuate anomalies of interest using reduction-to-equator and regional–residual anomaly separation filters. Thereafter, subsurface lineaments were extracted and their depths estimated.The VES data were interpreted quantitatively by partial curve matching technique and 1-D computer assisted forward modeling. The results were used to identify aquifers, determine geoelectric parameters, overburden thickness and electrical coefficient of anisotropy for each of the VES. The lineament density, lineament intersection density, lithology, slope, coefficient of anisotropy and bedrock elevation maps were integrated in ArcGIS to produce the groundwater potential map of the study area.

The aeromagnetic map revealed various relatively short and long wavelengths elongated anomalies diagnostic of relatively shallow and deep two-dimensional (2D) magnetic bodies respectively. The lineament orientation analysis showed that the study area is dissected by

several surface and subsurface linear structures, among which the ENE-WSW, WNW-ESE, NNE-SSW, and NNW-SSE trends dominated. The depth of occurrence of the subsurface lineaments ranged from < 50 to 200 m. The lineament density map revealed five (5) lineament cluster zones in the range of 0.00 – 0.90, 0.90 – 2.00, 2.00 – 3.26, 3.26 – 4.45 and 4.45 – 5.68 / km^2. Five (5) subsurface geologic layers which included the topsoil, lateritic layer, weathered layer, partly weathered / fractured basement (PWFB) and the fresh bedrock were identified. The weathered layer and PWFB constituted the aquifer units. The overburden thicknesses ranged from 0.40 to 129.00 m. Relatively low overburden thicknesses were observed at regions underlain mostly by porphyritic granite, granite gneiss and banded gneiss lithologies. Relatively high overburden thicknesses were observed at regions underlain mostly by undifferentiatedschist and quartz schist lithologies. The overburden coefficient of anisotropy ranged from 1.0 to 3.04. The synthesis of the lineament density, lineament intersection density, lithology, slope, coefficient of anisotropy and bedrock elevation maps in a GIS environment enabled the characterization of the study area into five different groundwater potential zones of very low, low, moderate, high and very high.

The study concluded that although low groundwater potential dominated the study area, there were zones with moderate and high groundwater potential.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The use of remotesensing and Geographic Information System (GIS) methods for mapping of surface to near-surface geologic structures (lineaments) is gaining prominence both in terms of techniques and applications. Traditional methods of mapping faults require fieldwork investigations. However, field-work is usually time consuming and may take up to years to complete, depending primarily on the extension and/or the accessibility of the area under investigation, topography, erosion, over-growth of vegetation, scale, experience of the geologist and other factorsthat control fault determination on the field (Cracknell and Hayes, 1991). On the other hand, remote sensing has the advantage of providing synoptic overviews of the region; thus it may directly pinpoint the characteristics of structural geological features extending over large areas (Drury, 1987). As added advantage to fieldwork investigations, remote sensing along with image processing techniques accounts for a less time-consuming and a more cost-effective method for fault detection,because such techniques in no way replace field investigations, but on the contrary they complement each other.For this study, lineaments can be defined as linear features corresponding to faulting, fracturing, geomorphology or vegetation trends. These features may be indicators of solubility of the rocks and can be associated with cavern/fissure conduits(Carla *et al.,* 2010).Studies have revealed that mapping of regional faults can be associated with zones of high permeability and concentrated groundwater flow(Meijerink, 2007). Remote sensing technology isvery efficient for data acquisition. Computer technology, suchas computer-based GIS,supplies a different method for data storage, integration,analysis, and display. The combination of

remote sensingand GIS provides an optimum system for various geologicalinvestigations such as fault mapping of large and inaccessibleareas(Chen, 1992).

The application of potential-field method suchas magnetics in geophysical prospecting can allow themapping (at local and regional level) of geologic structures such as faults and lithologic contacts that do not appear on the groundsurface.Themapping of such features is of socio-economic importanceas they can be used to identify possible flowpatterns of groundwater (Blakely and Simpson, 1986; Constant *et al.,* 2010; Sultan *et al.,* 2015).

The Electrical Resistivity (ER) method can be integrated with the Magneticmethod to provide reasonable results andclear picture of the subsurface formations. The ER method is one of the most promising geophysical tools whichis used for groundwater investigation due to its ability to provideuseful information about the subsurface structure and lithologyat reasonable depths (Keller, 1967; Mansour, 2009; Sultan and Josef, 2014).

This research work focuses on using integrated geophysical methods, involving GIS-remote sensing, magnetics and electrical resistivity for mapping the aquifer, structural elements (lineaments) dissectingthe study areaand for the determination of the depth to the basement in the Northeastern part of Osun state.

1.2 Description of the Study Area

The study area is Northeastern part of Osun state, Nigeria. It lies within longitudes 4°32′33″ Eto 5°03′28″ Eand latitudes 7°39′58″ Nto 8°05′43″ N (World Geodetic System (WGS)1984)(Figure 1.1).Expressed in the Universal Traverse Mercator (UTM) coordinates of Zone 31 using WGS 1984 datum: Eastings669962mE and 726993mE and Northings 847692mN and 895404mN respectively.It coversseven (7) Local GovernmentAreas (LGAs) namely:Odo-otin, Boluwaduro, Ila, Ifedayo, Ifelodun,Boripe, and Obokun LGAs. The study

area covered about 2,700 square kilometers andeasily accessible through network of roads and developed footpaths.

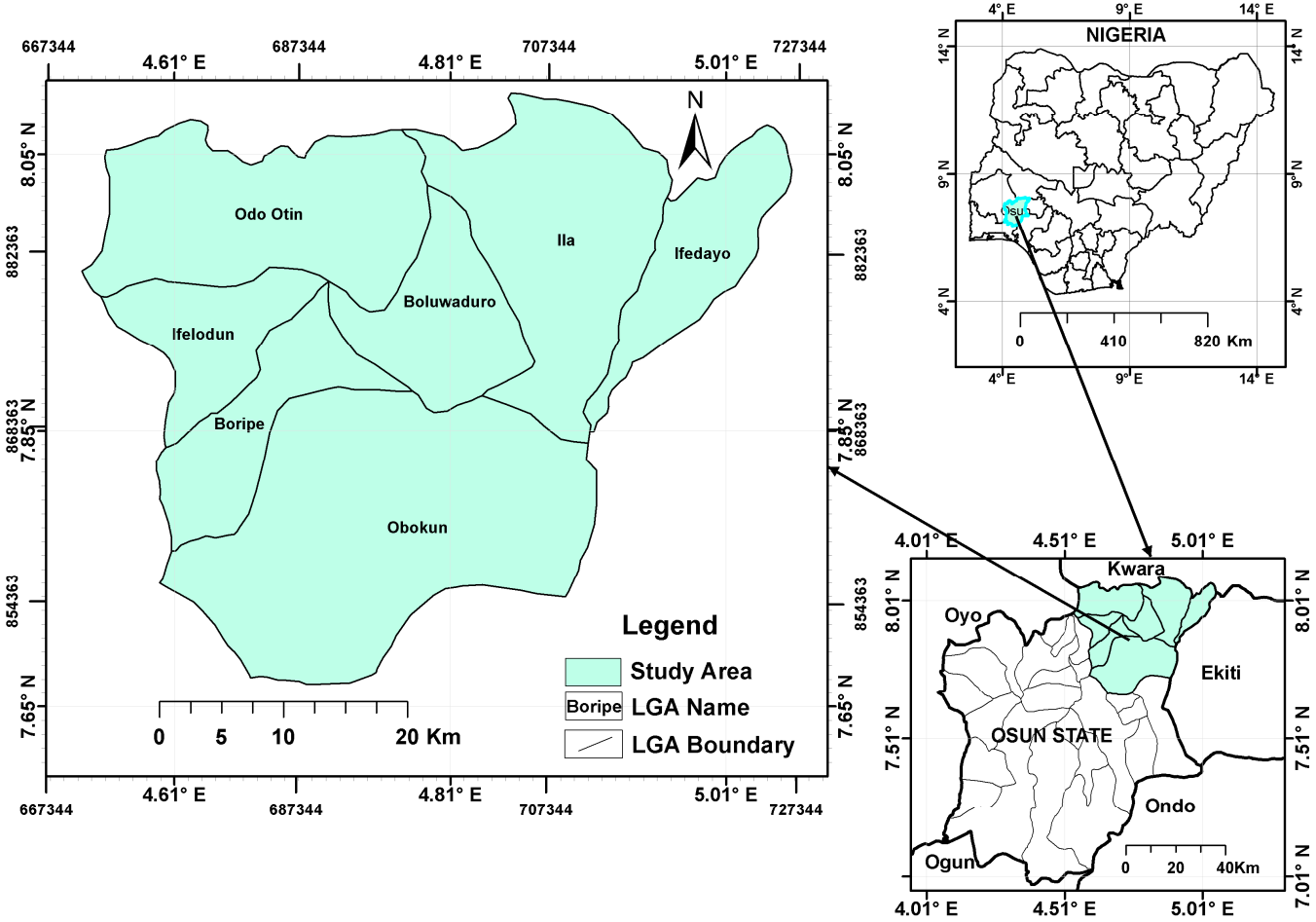

Figure 1.1: Location Map of the Study Area.

1.3 Relief, Climate and Vegetation