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Integrating Aeromagnetic and Landsat™ 8 Data for Geologic Features of Igbeti Schist Belt, Southwestern Nigeria: Implication for Groundwater Exploration

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Abstract

In an attempt to establish the geologic structures in connection with the assessment of groundwater resources within Igbeti crystalline basement complex terrain, Landsat 8 and aeromagnetic data were analysed using various sub-menus of Geographic Information System (GIS) and 2D Fast Fourier transform filters, respectively. Visual and automated models of the landform types and relief, the range of color composition of the Landsat 8 data controlled by the climato-morphogenic processes and alternating positive and negative magnetic anomalies revealed the contrasting lithologic units in the basement rock of the area. Lithologic contacts were developed with a vertical gradient while the linear features decipher the fracture orientation in concordance with a northeast-southwest low gradient trend. The associated groundwater flow direction revealed catchment in the northern, northwestern and southern parts of the area and indicated low run off, more infiltration time and better recharge potential for these regions, while zones of high degree indicated otherwise. The hydrology potential for groundwater development in the area should be targeted at geologic deformation.

Keywords

Geologic structures • Groundwater resources • Crystalline basement complex • Landsat 8 • Aeromagnetic

1 Introduction

Igbeti is a sub-urban area in the hard rock terrain of southwestern Nigeria (Fig. 1), generally classified as a poor groundwater potential zone [5, 9] due to its lack of primary porosities and permeability needed to make a good aquifer. Its dwellers do not have access to pipe-borne water supply as a result of economic water shortage; where the government cannot provide the necessary infrastructure to exploit water from rivers and aquifers. They, therefore, rely on shallow hand-dug wells with invariably low yield and susceptibility to pollution. Therefore, for meaningful groundwater exploration surveys in these terrains, the focus is anticipated largely towards delineating geologic structures (such as fractures, faults and weathered parent rocks), which create secondary porosities that may make crystalline rock formations aquiferous and, hence, exploitable as suggested in [1, 4].

2 Materials and Methods

2.1 Data Set

Landsat8 image (Path/Row-191/054) of 15 m resolution and aeromagnetic data of sub-nanotesla resolution scale were obtained from MapMart© and Nigeria Geological Survey Agency (NGSA), respectively. The Landsat image was captured on 4th February, 2014, using the Operational Land Imager (OLI) sensor at 10:03:33 am while the azimuth of the sun was 130.8° and the solar elevation angle at 52.14°, while the aeromagnetic data is part of the acquired dataset of total

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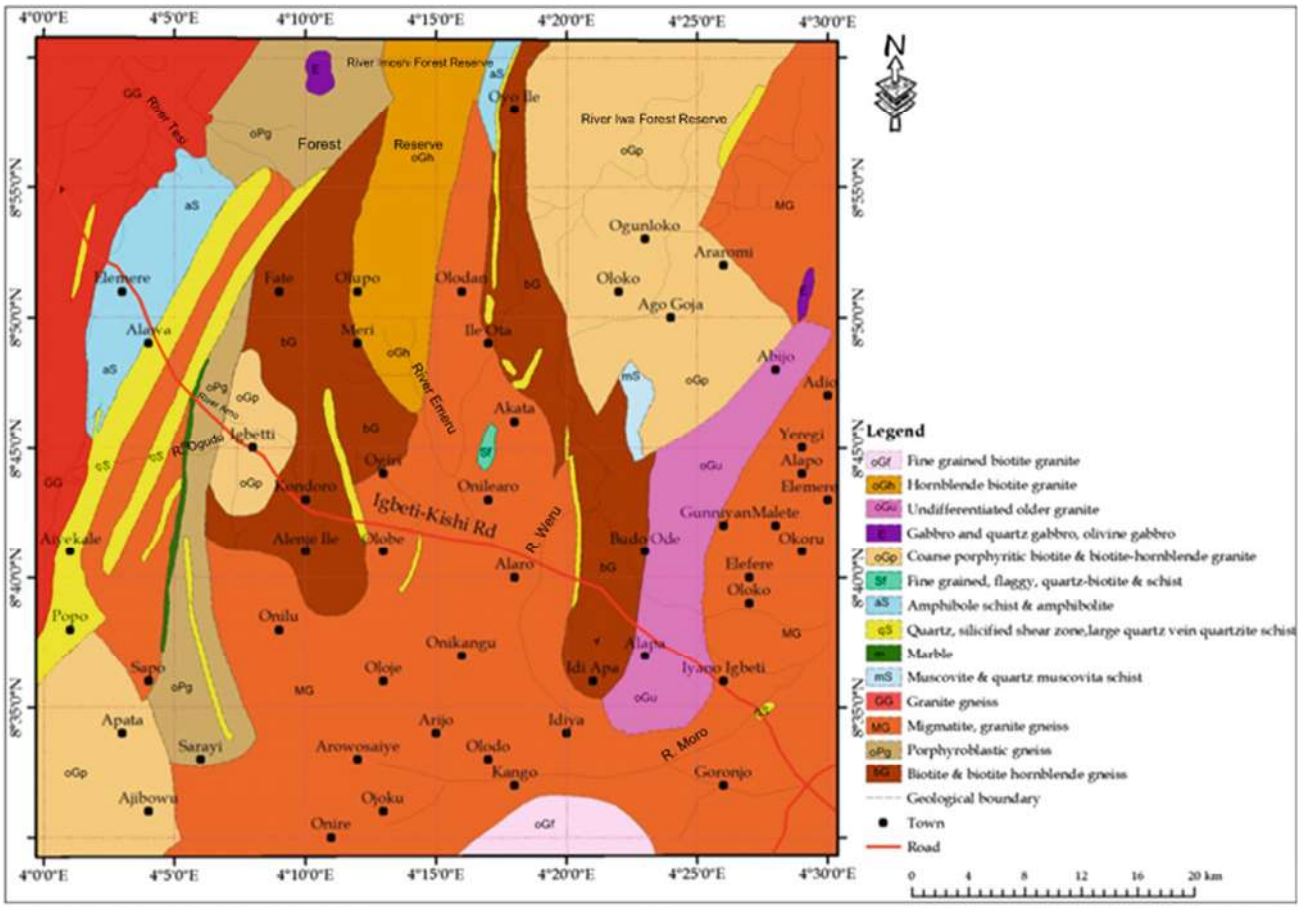


Fig. 1 Geological map of the area showing the major geological components

field magnetic intensity for Nigeria Geological Survey Agency (NGSA) between 2003 and 2009.

2.2 Data Processing

Elevation model (DEM) was digitally manipulated to produce thematic layers that include land-use, topography, slope maps and drainage network systems. Principal component analysis (PCA) and band combination were applied to the Landsat 8 data. The aeromagnetic data was de-cultured, leveled and corrected for international Geomagnetic Reference Field (IGRF) in concordance with [7]. The complex information provided on the TMI map was simplified using reduction to magnetic equator (RTE) as covered in [3]. Then, to improve the data quality that reveals the edges of rocks and structures, a vertical derivative VDR map was developed using the approach of [6].

3 Results

Morphology, roughness and texture relating to each lithology in the enhanced FCC-741 color and RTE residual magnetic anomalies (RMA) within a range of 338.3–208.0 nT are as shown in Fig. 2. The linear features are conspicuous as regions of low magnetic gradient on vertical derivative (VDR) map (Fig. 3a) which were traced on Fig. 3b. Slope map and single band D8 model showing surface and groundwater flow are depicted in Fig. 4.

4 Discussion

The range of color composition of the Landsat image (Fig. 2a) indicated contrasting lithologic units in the basement rock of the area, as corroborated by alternating positive and negative magnetic anomalies, which range between

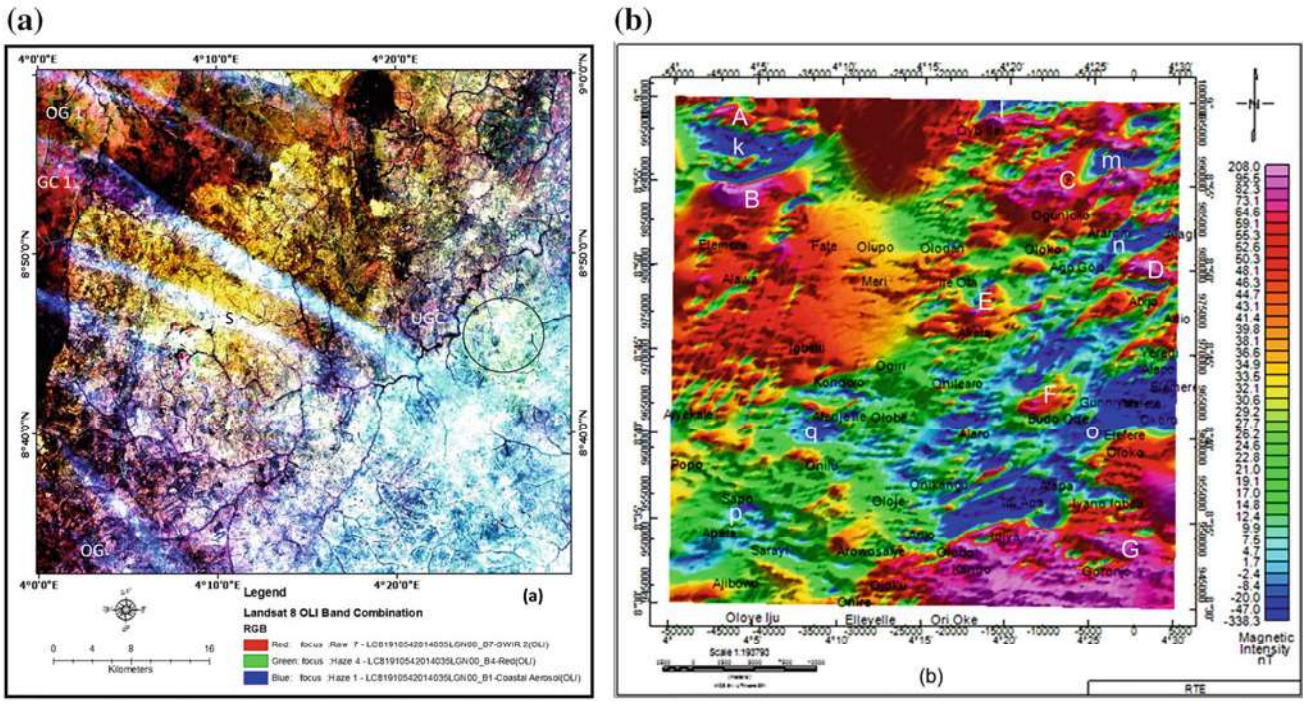


Fig. 2 **a** Landsat 8 and **b** RTE-residual magnetic anomaly maps

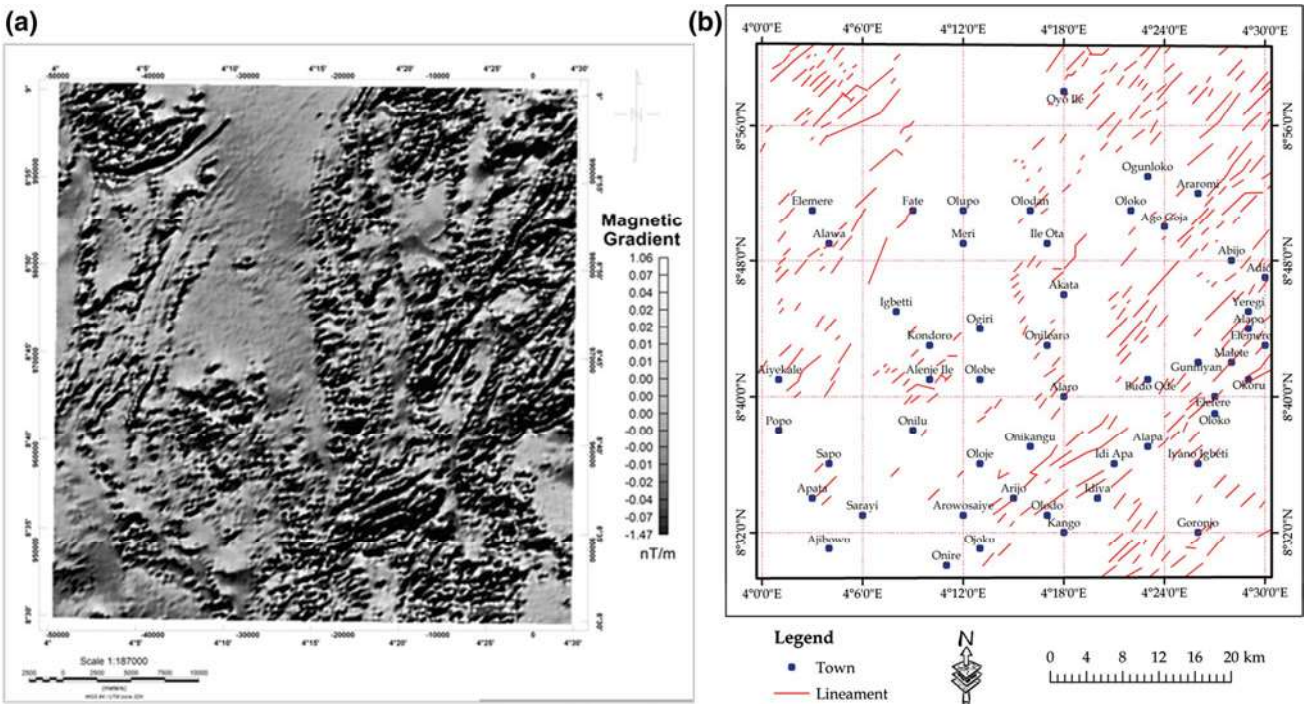


Fig. 3 Structural **a** VDR and; **b** lineament maps

−338.3 and 208.0 nT. The low magnetic anomalies coincide with the intrusion of older granitoids (OG) and/or rocks of lower content of ferromagnetic minerals viz, undifferentiated older granite and biotite granite (UGC), while the high anomalies correspond to the gneiss complex (GC) rocks, which are traversed by intermediate and low magnetic linear features (S). The intermediate magnetic anomaly signatures are interpreted as fractures and/or sheared zone associated

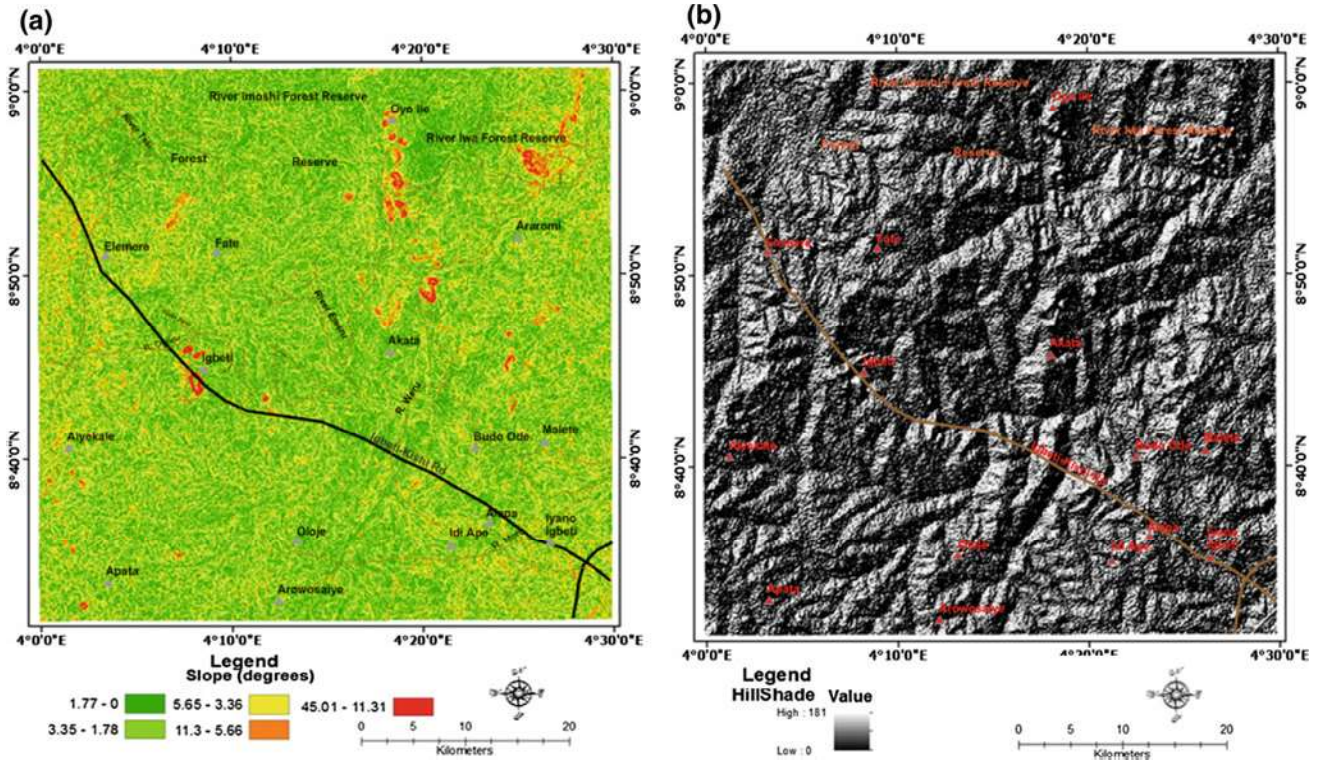


Fig. 4 **a** Slope and; **b** D8 drainage maps

with depletion of magnetite [8], and in concordance with predominantly NE–SW trending lineaments, which provided more information on the regional deformation and suggested relict imprints associated with Pan African orogeny [2]. The northeast–south trending low gradient (within 0°–11.3°; Fig. 4a) coincides with the fracture trend and drainage direction (Fig. 4b), which attributes to catchment in the northern, northwestern and southern parts of the area.

5 Conclusions

The geomorphology and geologic structures obtained from high resolution Landsat 8 and aeromagnetic data of Igbeti and its environs have deciphered its groundwater prospect. The high degree of fracturing within a low gradient region in the northeastern, north-central and western parts of the area indicates low run-off and better aquifer recharge potential, while zones of high gradient may experience otherwise. The hydrology potential for groundwater development in the area should be targeted at geologic deformation.

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