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SPECTRAL SIGNATURE OF SHALLOW GROUNDWATER IN THE BASEMENT COMPLEX ROCKS OF WUDIL AREA (SHEET 81), CENTRAL NORTHERN NIGERIA

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ABSTRACT.

Sheet 81 (Wudil) is enclosed within the Landsat5_TM scene,number LT5188052008702010 that was acquired in January 1987. The sheet was clipped from the main scene data and image processing was carried out at a scale of 1:100,000. The processing was done using ERDAS Imagine version 8.3.1. The area under study is underlain by rocks of the basement complex comprising mainly gneisses.

In this study, spectral information was used for assessing groundwater potential in the area. A careful study of a number of combinations of spectral bands enabled the characteristics of some to be maximized. The resulting interpretation of the distribution of vegetation, its lushness and pattern and, moist surfaces or discharge areas was combined with borehole information on depth to groundwater table in the area, and these formed the basis for dividing the entire area into zones having different groundwater potentials since these features are believed to have a direct relationship with the occurrence of groundwater.

This approach will find useful application in regional groundwater investigation aimed at rural groundwater supplies in areas having basement complex geological terrain.

Key words: **Landsat5_TM, Spectral, Groundwater, Basement complex.**

INTRODUCTION.

In the application of remote sensing imagery to groundwater studies in areas underlain by rock of the basement complex of Nigeria, zones of different groundwater potentials have often been defined in relation to lineaments or fractures. Such structural interpretation based on the location, density and intersection density of fractures were used to assert that increase in well yield is related to lineament density, Okereke *et al.*, (1993), whilst Edet *et al.*, (1994) used same to differentiate areas of deep from those of shallow groundwater, stating that high lineament density is associated with outcrop areas which contain shallow groundwater. Similarly, Odeyemi *et al.* (1999) draws attention to their usefulness in groundwater occurrence. However, Bala *et al.*, (2000) delineated zones of different groundwater potentials by using fractures and other information on an imagery relevant to groundwater.

Groundwater cannot be detected directly on an imagery. But since the wavelengths of electromagnetic radiation commonly used in remote sensing are either in the reflected or emitted range from the surface or very shallow layer below ground surface a careful study of the spectral information on an imagery can yield reliable evidences which can be related to groundwater resources of an area. In this paper, an attempt has been made to delineate shallow groundwater areas based on spectral information contained in transformed Landsat thematic mapper data.

THE STUDY AREA.

Sheet 81 Wudil is located within longitudes 8° 30"E - 9° 00"E and latitudes 11° 30"N - 12° 00"N. It covers an area of about 2954km², (Fig. 1). The climate consists of a dry and a wet season. The rainy season lasts from May to October and the mean annual rainfall is about 800mm. The dry season is characterized by low

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Table 1. Some information on boreholes within the zone of shallow groundwater

S/ Nº	Location	Coordinates (UTM 32/ North)	Depth (m)	SWT (m)	Yield (l/m)	Drawdown (m)
1	Katsinawa	8 31 39/11 47 42	31.5	9.9	70.0	0.96
2	Kumbotso	8 30 15/11 54 35	36.2	6.5	80.0	0.26
3	Iyatawa	8 34 10/11 48 30	31.5	12.8	80.0	0.17
4	Santolo	8 37 10/11 48 40	29.4	12.6	14.0	3.29
5	Tsakuwa (Pansalla)	8 37 10/11 48 10	37.0	11.6	54.0	3.38
6	Kunshama	8 36 16/11 45 46	49.0	3.2	27.0	18.15
7	F. Gidan Kwari	8 32 48/11 45 30	37.0	13.7	82.0	8.31
8	Jaroji	8 36 00/11 43 38	33.0	14.1	14.0	8.33
9	Gurjiya (Mariri)	8 33 30/11 33 40	32.0	11.6	82.0	59.9
10	Muras	8 38 20/11 44 40	41.0	2.4	56.0	2.37
11	Baradai (U. Ruwa)	8 41 40/11 44 00	30.0	5.9	90.0	8.1
12	Dosan	8 40 05/11 57 20	34.0	12.7	53.0	2.57
13	Basaima	8 41 50/11 47 20	28.0	9.9	38.0	8.88
14	Dan Bagina	8 47 30/11 48 30	40.5	12.1	69.0	5.91
15	Dan Idris (Gara)	8 46 40/11 46 50	29.5	11.1	69.0	0.15
16	Kamagata	8 45 55/11 46 15	31.5	8.7	57.0	0.45
17	Minchika	8 53 00/11 50 50	65.0	11.4	08.0	13.39
18	Dadin Kowa	8 53 20/11 54 50	43.5	9.9	60.0	6.61
19	Katarkana	8 50 00/11 58 00	57.0	7.9	06.0	16.65
20	Cirin	8 31 28/11 37 58	46.8	11.7	51.0	10.88
21	Gidan Deri	8 31 30/11 31 40	32.0	16.0	21.0	9.78
22	Zone I HQ	8 32 05/11 30 15	36.0	12.5	10.0	33.56
23	Zanyau	8 33 48/11 30 07	37.5	11.7	72.0	2.71
24	Rano	8 34 30/11 33 00	8.7	8.3	–	–
25	Zanbur	8 33 11/11 34 06	64.0	11.7	10.0	33.13
26	Faram	8 37 43/11 31 27	34.8	6.3	16.0	7.63
27	Shike	8 32 52/11 30 30	28.5	7.8	73.0	3.58
28	Kibiya	8 39 40/11 31 40	3.8	3.5	–	–
29	Bacha	8 39 32/11 35 00	46.8	12.1	19.0	2.61
30	Narya	8 47 10/11 29 15	37.0	2.5	30.0	9.56
31	Kure	8 45 30/11 30 50	37.5	3.1	70.0	24.53
32	Kuluki	8 44 15/11 33 20	20.5	9.4	90.0	1.71
33	Famar	8 43 13/11 33 20	31.5	9.7	65.0	6.35
34	U. Gai	8 43 00/11 35 30	31.5	11.9	20.0	9.60
35	Kadigawa	8 44 16/11 35 10	31.5	10.8	77.0	1.30
36	Zakarawa	8 49 30/11 33 40	29.0	8.0	67.0	4.19

Source: RUWASA, Kano.

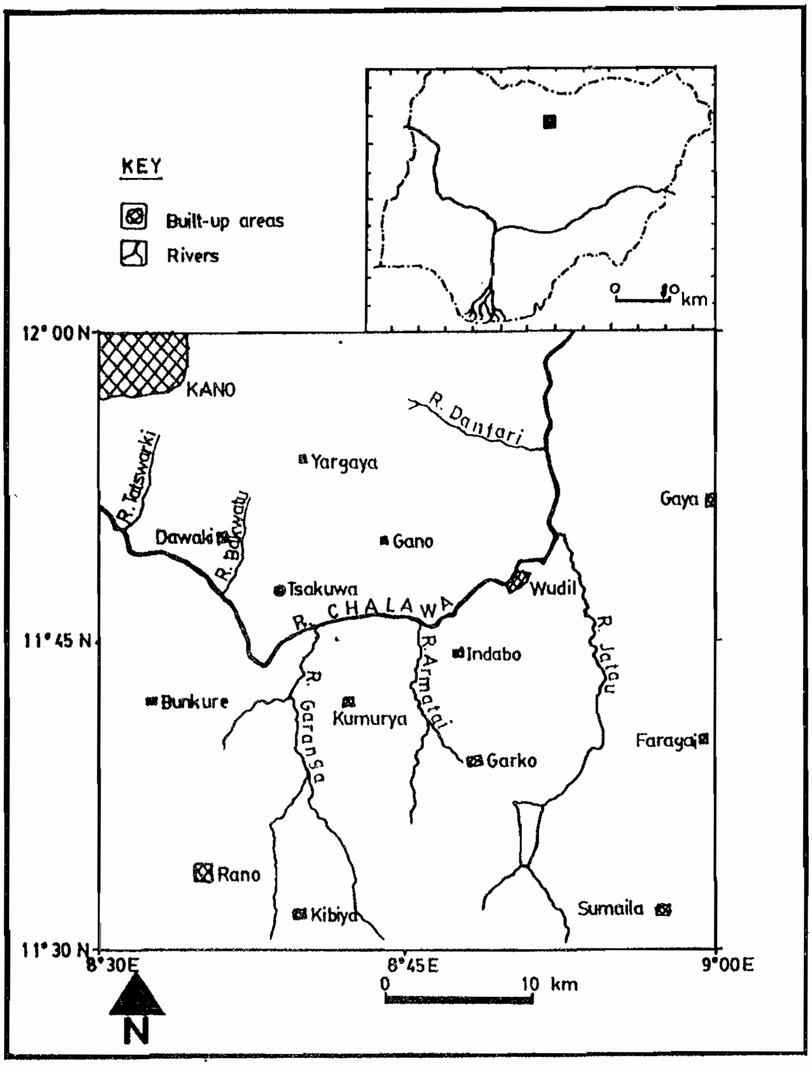

Fig. 1. Location and drainage map of Wudil area.

humidity and high day time temperatures. The native vegetation is typical Sudan savanna which is characterized by thorn bushes and scattered shrubs.

Wudil sheet is still planimetric. The area shows a generally undulating topography. The highest elevation of about 638m is found in the extreme southwestern part while in the northwest and north-central the elevation varies from about 466m - 486m. The main drainage element in the area is the Chalawa.River Chalawa has as its tributaries, the Charanga, Armatai and Jatau on the southern part, and the Tatsawarki, Bakwatu and Danfari on the northern section. The main river and the southern tributaries are structurally controlled and all the tributaries are seasonal. The whole area is underlain by rocks of the basement complex. Common varieties of rocks are granite gneiss and migmatitic gneiss. However, in the southwestern part outcrops of coarse porphyritic granite of the older granite suite are found.

MATERIALS AND METHOD.

The clipped imagery, sheet 81 was processed at a scale of 1:100,000 using ERDAS Imagine 8.3.1 software. A first principal component analysis was first performed on the imagery following which outcrops in the area were marked out. Then the tasseled cap transformation (Crist *et al.*, 1986) was carried out to enable one to look at the resulting image in the three principle axes of brightness, greeness and canopy. The brightness axis was enhanced to improve image interpretability. The image was interpreted in RGB 123.

RESULT.

No groundwater discharge areas or moist surfaces were observed on the image, but three main signatures of groundwater are seen. These are magenta, green and cyan. Magenta dominates green and cyan in the northern part, green dominates magenta and cyan in the central to southeastern while cyan is the signature in the southwestern part of the area. Using the signatures together with depths to water table measured in May 2000, and those recorded by drillers available from KNARDA, Kano (Table 1), it became clear that the cyan signature is found in areas having shallow water table. These pieces of information formed the basis for dividing the area into different groundwater zones, (Fig. 2). Two main groundwater areas namely, non-groundwater (represented by outcrop areas), and shallow groundwater zones, were positively distinguished on the basis of spectral analysis of the imagery. The rest of the area presents signatures which are significant for groundwater presence, but which are still being studied together with borehole lithological logs.

DISCUSSION.

In the centre of the area, shallow groundwater tends to follow the main river, River Chalawa. Since the river is perennial, this phenomenon can be expected, but more importantly is the significance of the fracture control on the river and therefore on the control on the presence of groundwater in the basement rocks. The structural control on the River Chalawa would have masked the spectral signature of shallow groundwater if the observation were limited to that river course. But in the southwestern part, the same spectral signature is recognized in a region which bears no relationship with water flowing in a channel.

The mean depth to water table in the areas designated as shallow groundwater is 9.60m (std. dev. = 3.50) while it is about 19m in the other areas. However, the drawdown in wells is quite high with a mean value of 9.70m (std. dev.

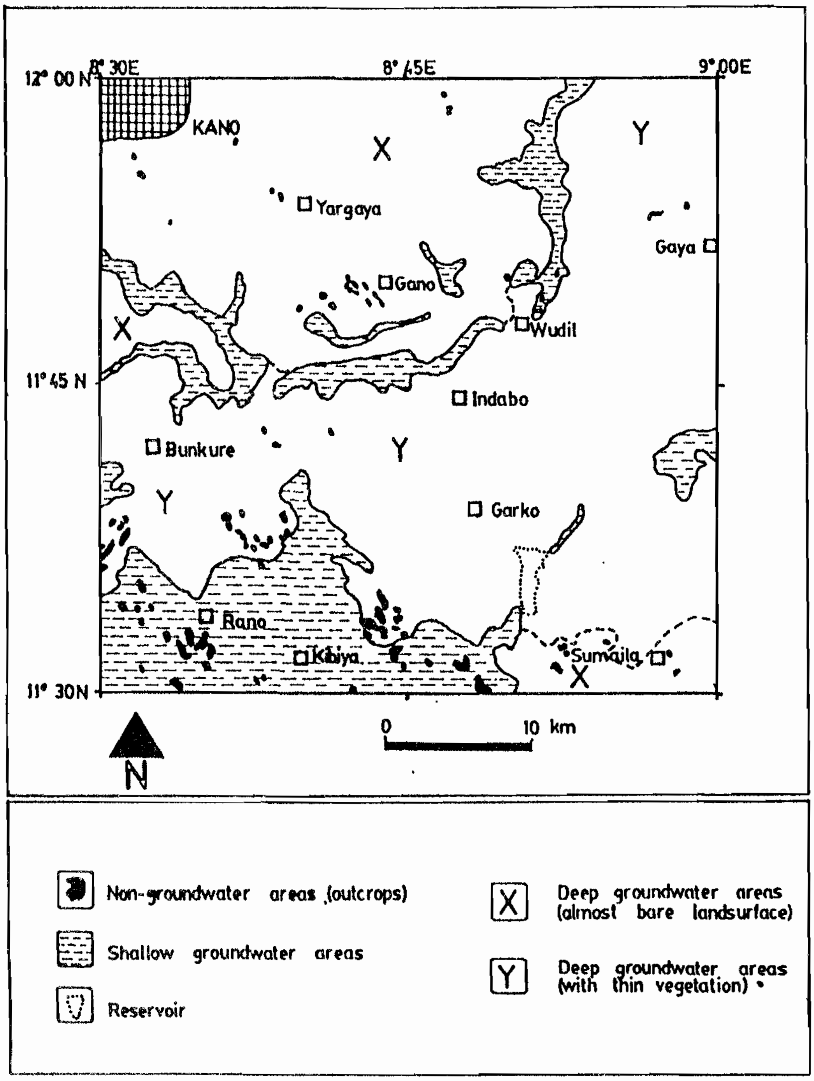

Fig. 2. Groundwater zones of Wudil area.

12.26) at an average pumping rate of 72.0m^3/day. This is an indication that the yield of water to wells in these areas is low (as in most areas underlain by basement complex rocks, Uma and Kehinde, (1994)). The specific capacity of the aquifer calculated using Table 1 varies very widely from 0.43/d/m at Zone I Headquarter to 677.65/d/m at Iyatawa with an average of 76.96/d/m.

Combinations of signatures are observed in the portions marked X and Y. Within those occupied by the former, magenta is dominant whereas it is green in the latter. With the aid of available information from borehole data on depth to water table, these areas are regarded as those having deep water table. Since the two signatures are unlike, more hydrogeological information is needed to fully distinguish between them. Furthermore, the use of vegetation alone to delineate groundwater areas should be handled with caution as vegetation vibrancy may sometimes be related to plant species and plant nutrients.

The purpose of surface geophysical investigations for siting boreholes is to locate areas with fractures, thick regolith, or deep regolith underlain by fractures. This is because these are the areas most favourable for the accumulation of groundwater. The use of spectral information is independent of fractures, and points directly to positions of groundwater beneath the surface and will therefore serve to cut down costs in groundwater investigations.

CONCLUSION.

The analysis of spectral signatures allows for zones having different depths to the water table to be easily identified. Since the cost of providing a borehole is related to the prescribed depth to be drilled, areas requiring shallow boreholes can be detected and appropriate drilling depths recommended thereby reducing costs for providing water to communities. In addition to this advantage, the decision to make open wells or drill shallow boreholes, and the number of intakes needed by a community can easily be taken.

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