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GEOLOGICAL ASPECTS OF ETM+ LANDSAT AND SRTM RADAR IMAGERIES ON PARTS OF CENTRAL NIGERIA

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ABSTRACT

Lithologic and structural interpretation of EMT+ landsat and SRTM radar imageries were carried out for parts of North Central Nigeria bounded by latitudes 9°11'21.80"N to 11°3'37.20"N and longitudes 7°43'53.00'E to 6°25' 50.60"E. Both visual and computer aided interpretation were performed using Arc Gis 9.2™, Multispec™, Ilwis 3.4™ and Microsoft Paint™. Dendritic drainage pattern dominates the northern part of the study area, and are associated with schists intruded by granites. Rectangular drainage pattern associated with mylonitic quarzites, dominates the South West section of the study area around Zungeru. Annular and braided drainage patterns are associated with resistant migmatites. Undisplaced lineaments on the north of Shiroro Dam indicate joints, while relatively displaced lineaments indicate faults. Lineament analysis indicates dominant joints trending NNE – SSW. Lineaments are concentrated on the portion defined by 6°20.00'E to 7°40.00'E and 9°10.00'N to 10°50.00'N. Exploration for primary gold mineralization and zones with adequate groundwater potential to meet urban needs, should be focused on this portion. Synforms and antiforms are common in North-West of the study area where lineaments are absent. This reflects the presence of plastic rocks and agrees with widespread outcrops of schists and pelites in this part of the study area.

Introduction

Landsat and radar imageries facilitate regional lithologic mapping and delineation of regional geologic structures such as joints, faults, synforms and antiforms. Different vintages of these imageries have been acquired over much of Nigeria. Lithologic and structural interpretation of ETM+ (enhanced thematic mapper plus) landsat and SRTM (Shuttle radar topographic mission) radar imageries were carried out for parts of North Central Nigeria.

Statement of Problem

Detailed lithologic mapping over extensive areas is cumbersome. Many parts of Central Nigeria are still remotely located, making field geological work in such areas particularly challenging. Regional structures such as regional faults, synforms and antiforms are often difficult to recognize in local field geological mapping. Yet these structures localize groundwater occurrence and solid minerals.

Detailed lithologic mapping over extensive areas and resolution of regional structures are easily achieved by lithological and structural calibration of satellite imageries.

Location of Study Area

The study area (Fig. 1) is defined by latitude 9°11' 21.80"N to 11°3' 37.20" and longitude 6°25' 50.60"E to 7°43' 53.00'E.

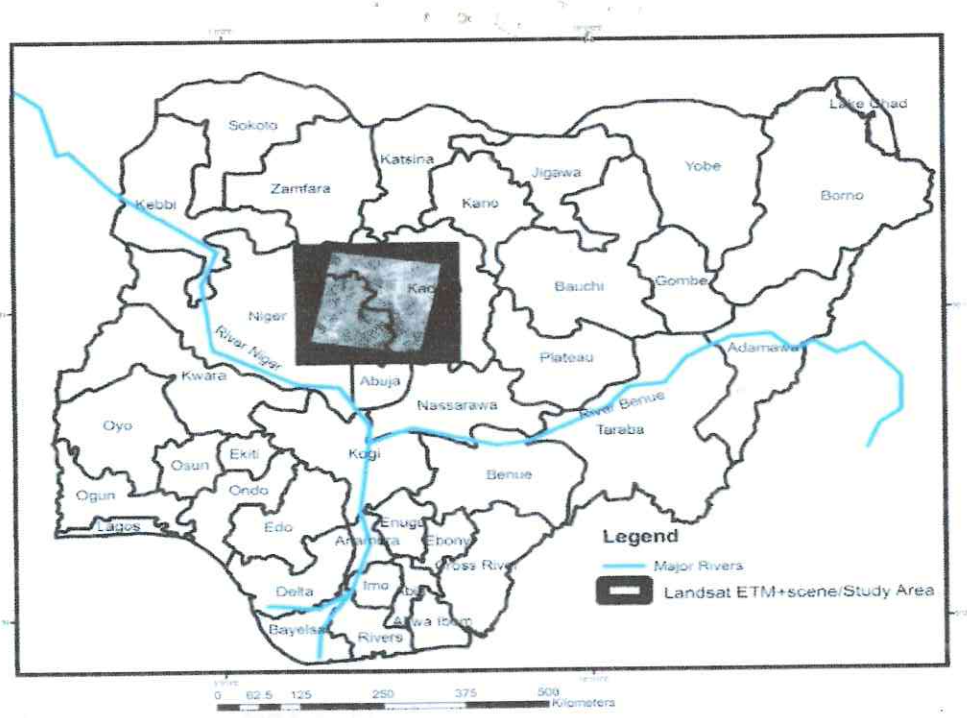


Fig 1: Map of Nigeria showing study area with its landsat ETM+ superimposed (ETM+ was down loaded via www.rsf.gsfc.nasa.gov)

Geological Overview

The area belongs to the Northern Nigerian massif of the basement complex (Fig. 2) and contains outcrops of granite, migmatites, gneiss schist and quartzite(Oyawoye,1972; McCurry,1976)

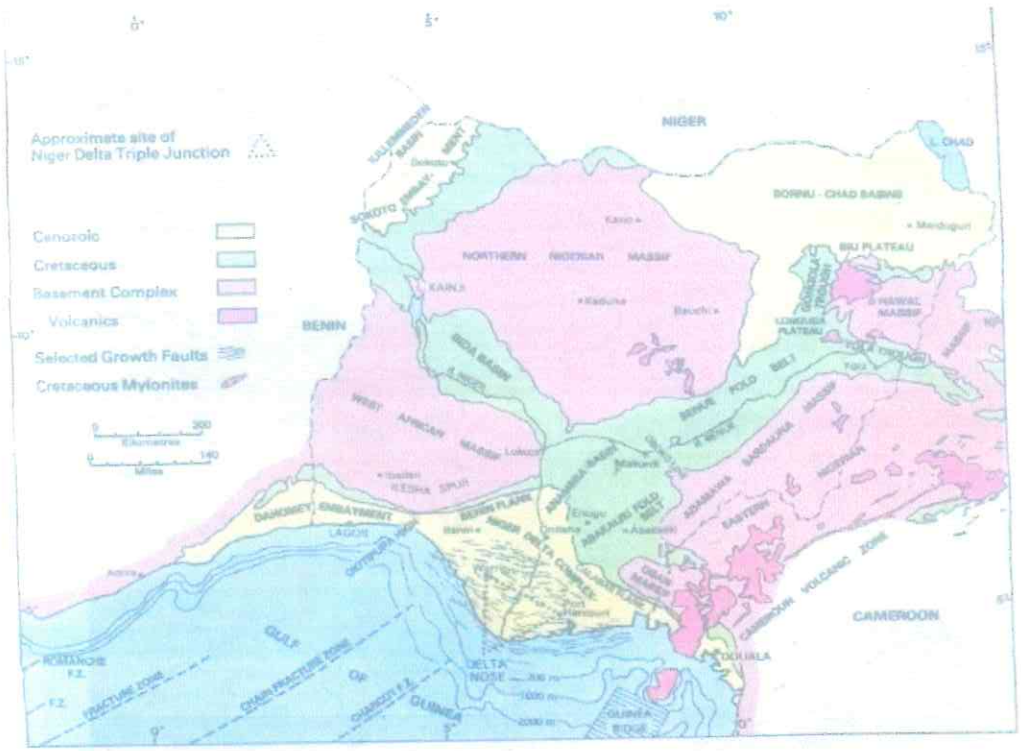


Fig 2: Geological Map of Nigeria (Whiteman, 1989)

Megascopic structures such as joints, faults and folds are present in the area. Regional geological map of the area is given as Fig 3.

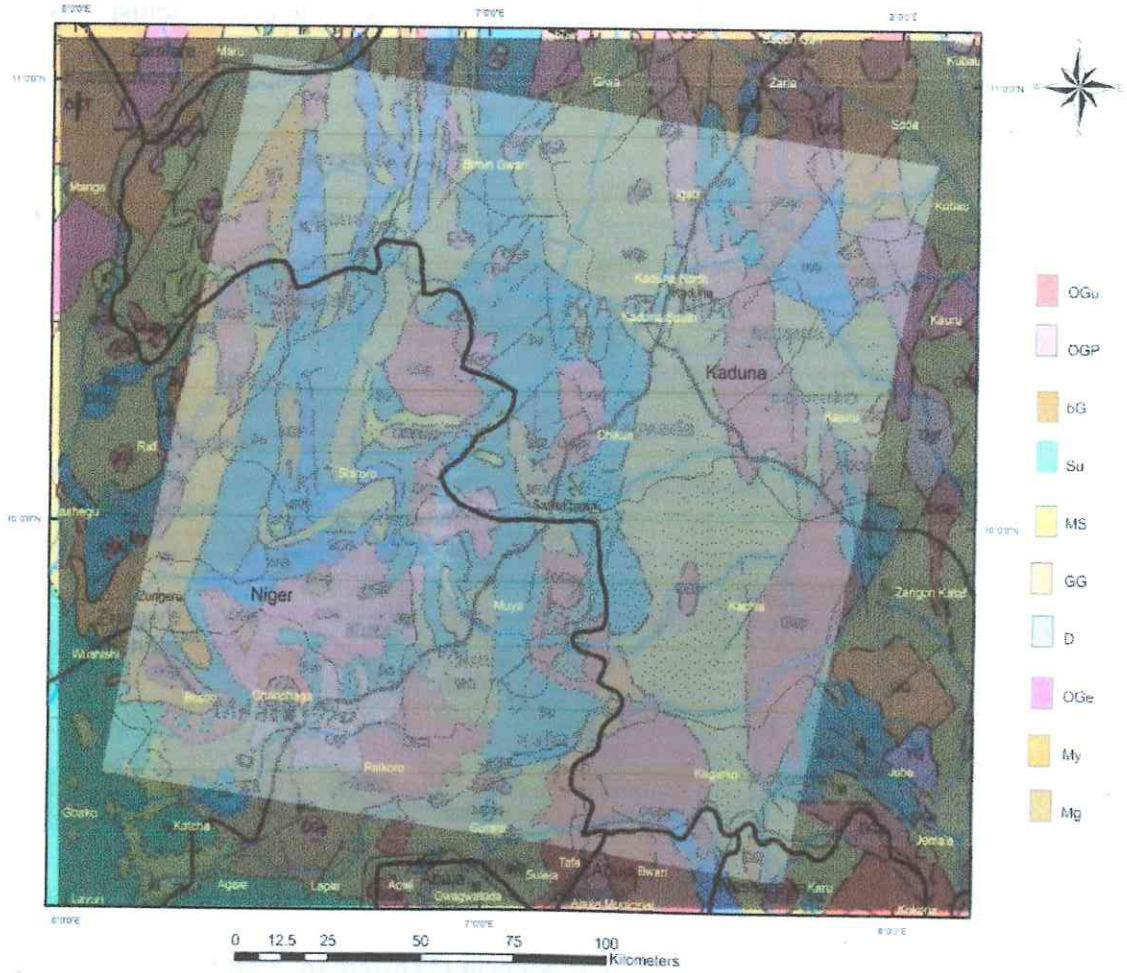


Fig 3: Regional geological Map of the Study Area (GSN, 2007)

Lithologic key of the map is as follows:
OGU: Undifferentiated granite, migmatites, gneiss.
OGP: Porpyritic granite / coarse biotite hornblende granite
BG: banded / biotite gneiss
SU: Undifferentiated schists, phyllites.
MG: migmatitic gneiss
MS: Pelitic / mica schist

Methodology
ETM+ Landsat and SRTM radar imageries were downloaded from Global Land cover Facility website (www.landcover.org.). Filtering using Interpretations were calibrated with field outcrops and geological map edge enhancement filters was done to enhance drainage patterns and lineaments appearance on the imageries. Seven bands of the landsat ETM+ were downloaded separately. Some of the bands were combined to give colour composite images. Interpretation of imageries was both visual and computer – aided, using Arc Gis 9.2^{Tm}, Multispec^{TM}, Ilwis 3.4^{TM} and Microsoft Paint ^{TM}.
Lithologies were inferred from drainage patterns on landsat imageries. Information on structural disposition, topography and relief were inferred from the radar imageries. prepared for the area by Geological Survey of Nigeria.

DATA PRESENTATION AND INTERPRETATION
Figure 4 is the drainage pattern map of the study area, prepared from the landsat imageries.

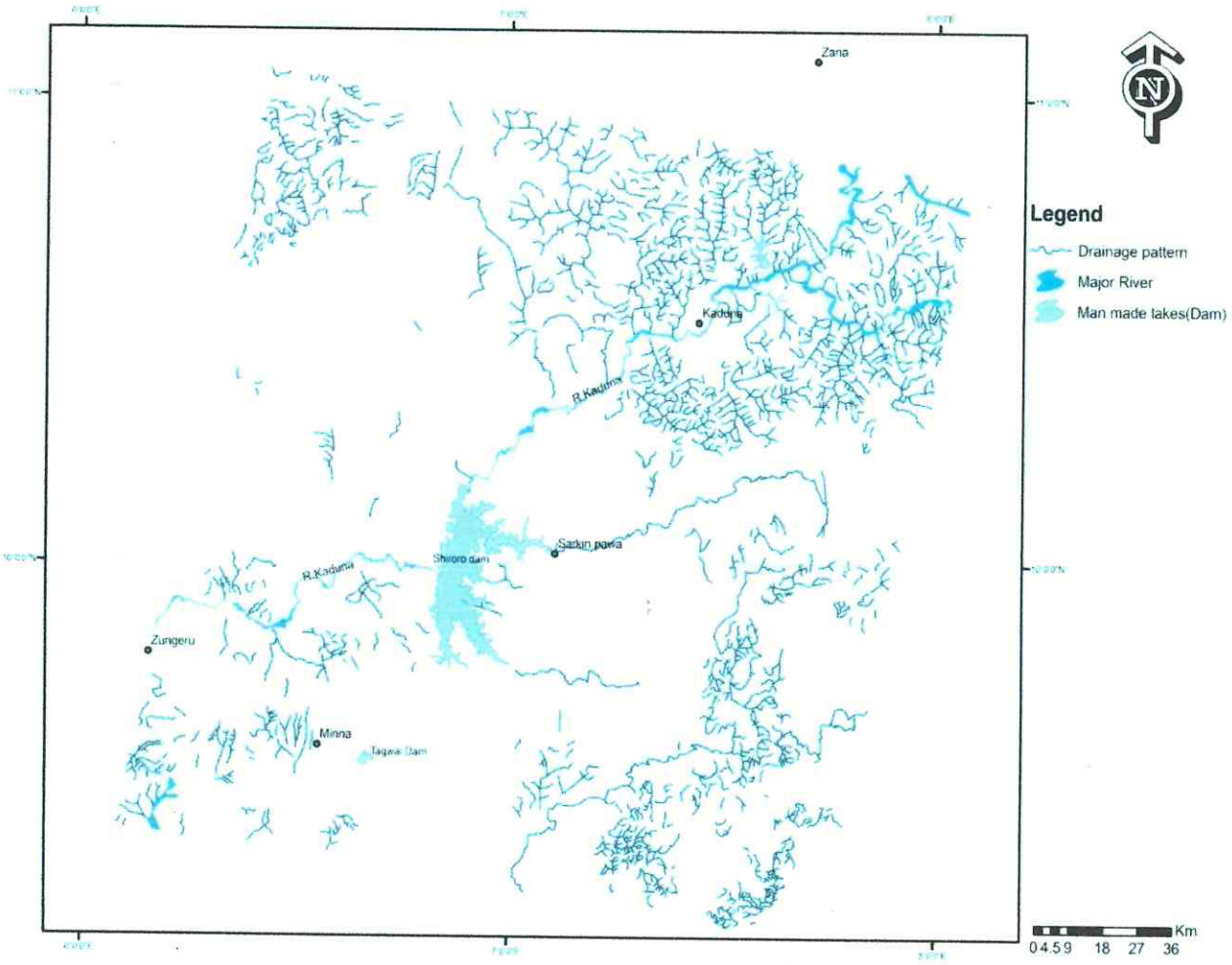


Fig. 4: Drainage pattern map of study area

Dendritic drainage pattern (Fig. 5) dominates the northeastern portion of the study area.

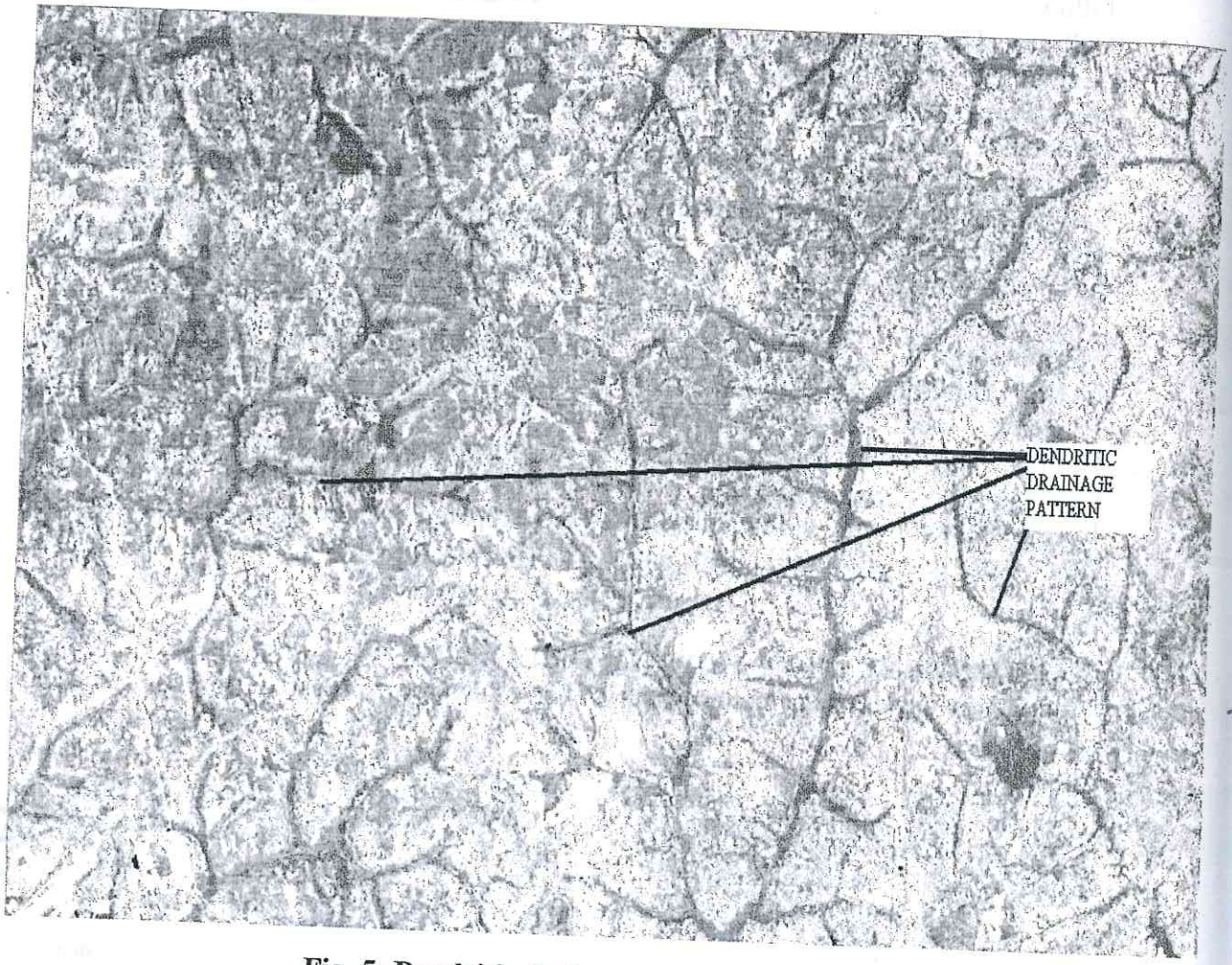


Fig. 5: Dendritic drainage pattern (major towns in this vicinity are Kaduna, Kujama, Kauruko)

This drainage pattern is commonly associated with schists and granite terrains within which structural control in lacking (Ravi, 2003). Geological map of the study area records outcrops of granite and schist in the area dominated by the dendritic drainage pattern. The granites are intrusions into the schists. Common around River Kaduna and Zungeru in the South West of the study area is the rectangular drainage pattern.

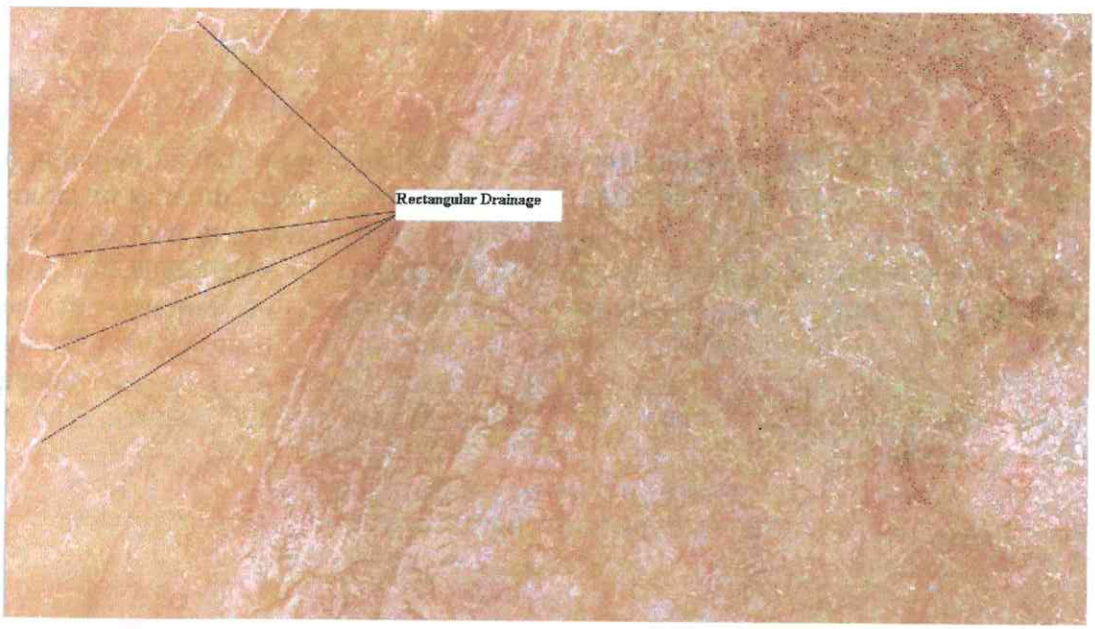


Fig. 6: Rectangular drainage pattern (major towns in this vicinity are Zungeru, Wushishi, Kagara)

This pattern reflects structural control in form of fractures (faults and joints) and is commonly associated with quartzites and sandstones. Quarzites (in the form of mylonites) outcrops extensively around River Kaduna in Zungeru. On the NNE neighbourhood of Shiroro Dam is annular drainage pattern. River Kaduna assumes this pattern to avoid obstructive resistant migmatitic ridges.

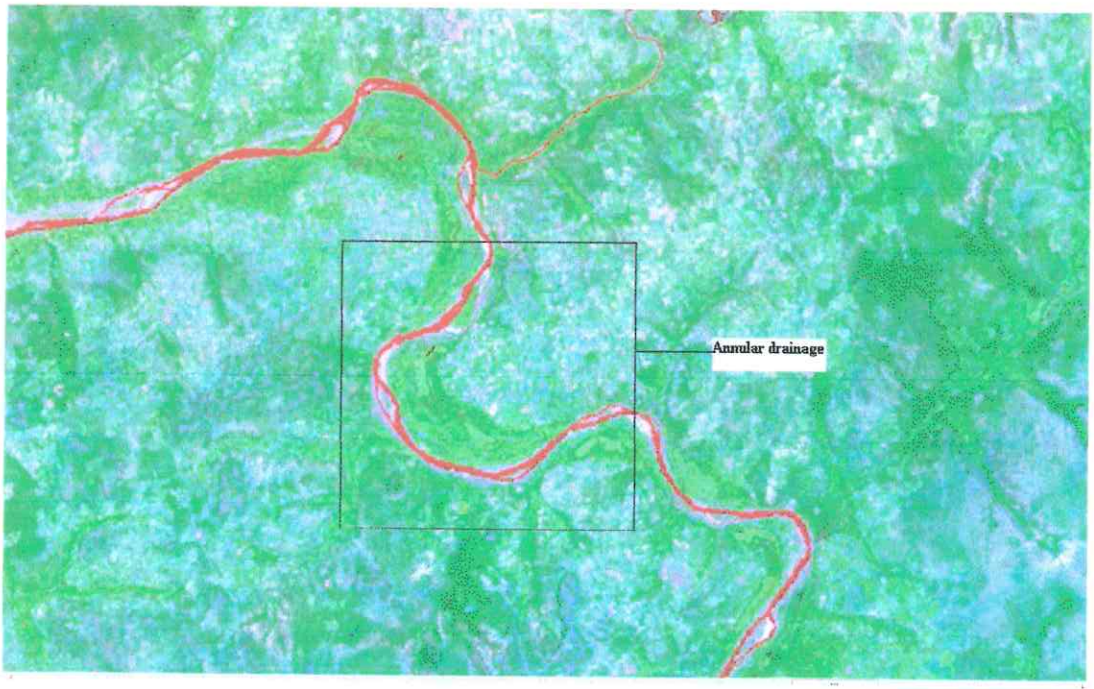


Fig. 7: Annular drainage pattern (major towns in the vicinity are Sarkin Pawa, Gwada, Chikum)

The annular drainage pattern is sometimes braided, still in response to underlying resistant migmatitic rocks.

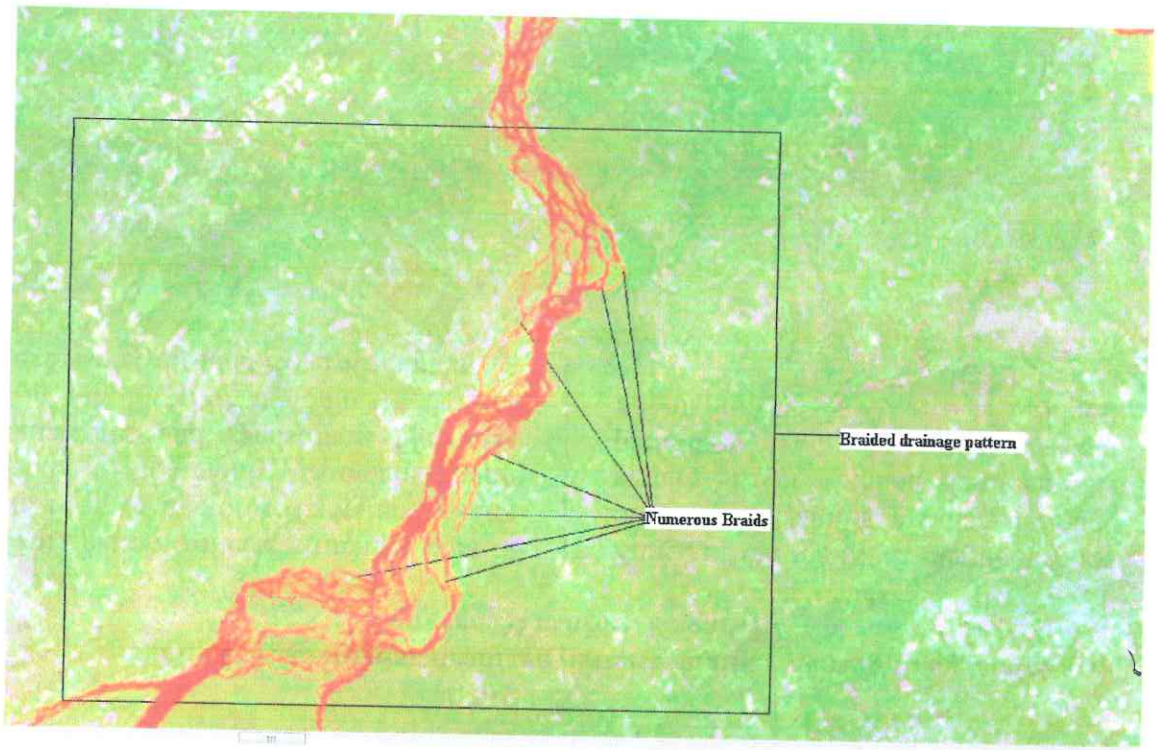


Fig8: Braided Drainage Pattern

At the braided portion of River Kaduna, the river is heavily loaded with sediments eroded from its banks. Due to inability to undercut the underlying migmatites, the river drops parts of its load in a branching pattern in order to flow on thereby generating the branding pattern. Linear pattern of differences in colour, tone, texture and features on satellite imagery show up as discontinuities. These linear discontinuities are lineaments. Undisplaced lineaments are joints. Fig 9 shows joints on outcrops north of Shiroro Dam in Chikun Local Government Area of Kaduna State.

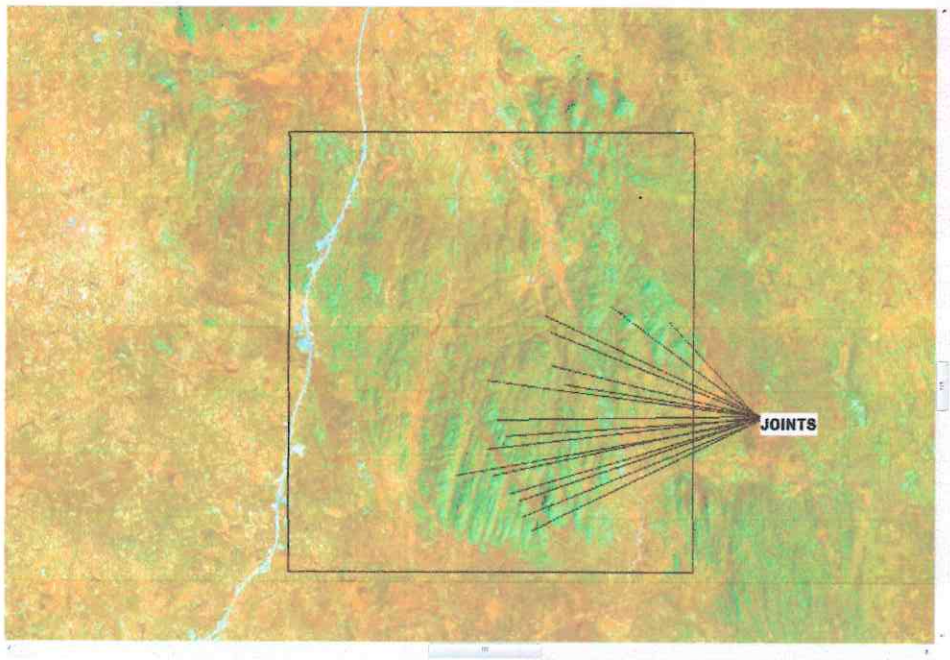


Fig. 9: Joint on north of Shiroro Dam, Chikun Local Government Area (Kaduna State)

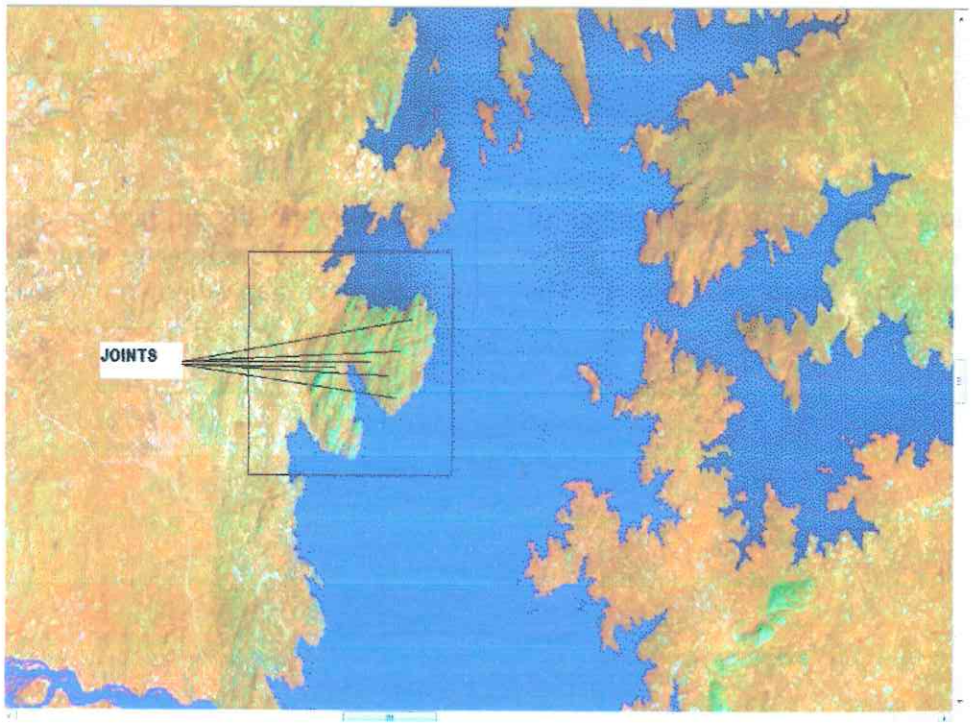
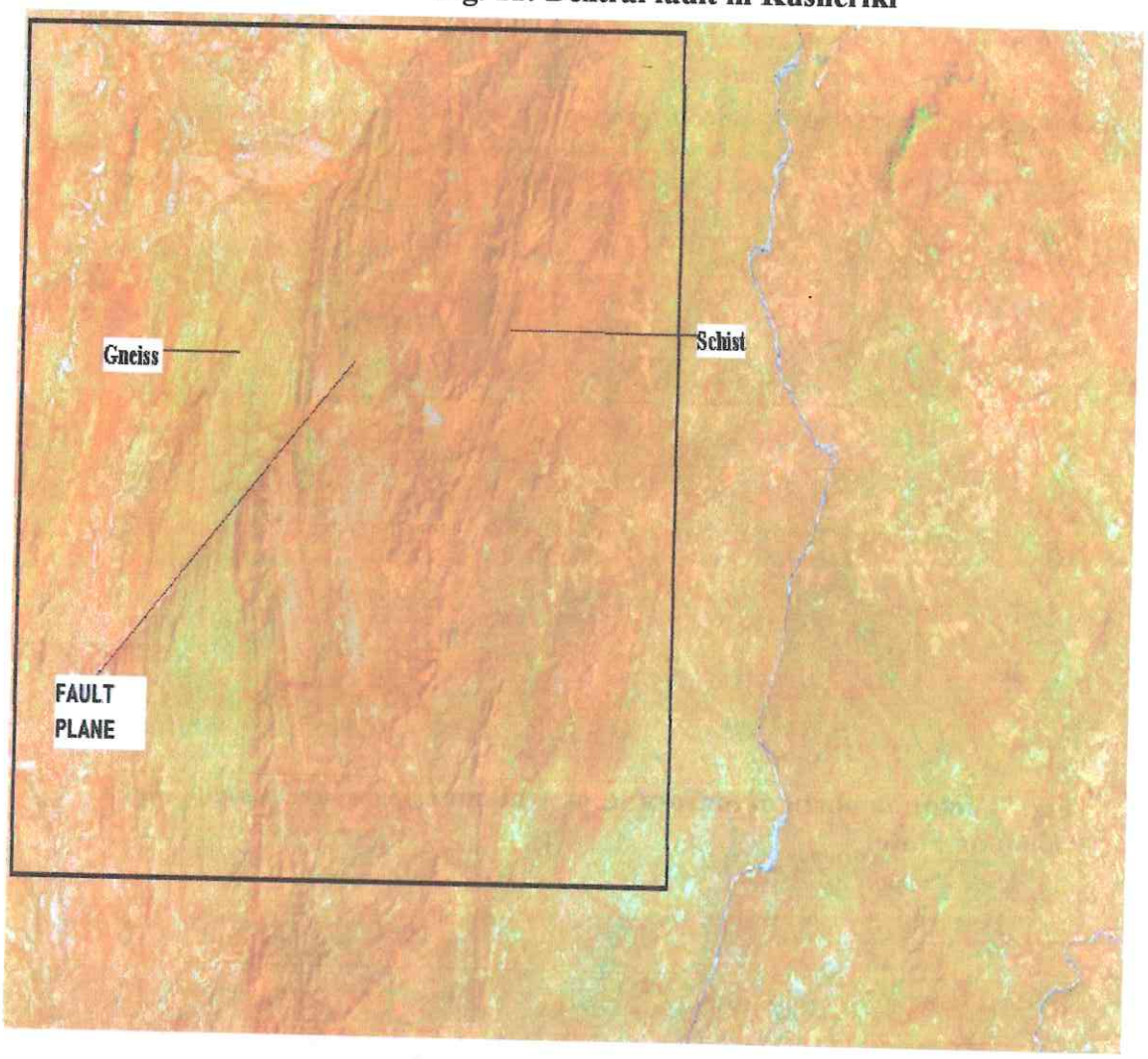


Fig10: shows joints on outcrops east of Shiroro Dam in Muya Local Government Area of Niger State.

Lineaments associated with relative displacements are faults. Fig. 11 is a 5 km long dextral fault around Kusheriki in Shiroro Local Government Area of Niger State.

Fig. 11: Dextral fault in Kusheriki



The length, direction and number of lineaments trending a particular direction are given in table 1. The resulting lineament map is shown in Fig12 while the Rosette diagram of the lineament map is shown in Fig 13.

Table 1: Length, direction of joints and number of joints in a direction

Direction	Length(m)	Number of Lineaments in Direction	Direction	Length(m)	Number of Lineaments in Direction
0	57437.1	42	51	8413.3	1
1	16823.2	10	52	0	0
2	16108	8	53	1469.4	2
3	14358	7	54	3613.2	5
4	8641	5	55	4654.4	3
5	15672.4	10	56	1510.7	4
6	15479.4	8	57	3901.2	2
7	14752.7	9	58	0	0
8	23039.9	12	59	2631.9	2
9	15392.4	13	60	3043.5	1
10	9973.6	10	61	2171.7	1
11	15579.4	8	62	5084.4	3
12	13157.7	8	63	3629.8	2
13	26737.9	16	64	1202.8	1
14	26315.6	13	65	1369.4	1
15	16195.7	8	66	3088.1	1
16	16092.3	8	67	8705.5	3
17	37425.2	12	68	3648.5	3
18	23375	11	69	1814.3	3
19	12314.8	7	70	0	0
20	15531.7	8	71	713.7	1
21	22377.3	11	72	2053.7	2
22	22586	9	73	2486.1	2
23	11959.1	7	74	467.1	1
24	18184.8	5	75	0	0
25	17832.5	4	76	2673.7	2
26	32117	9	77	953.3	2
27	28161.3	18	78	0	0
28	19290.7	10	79	2192.2	2
29	32679.8	9	80	1700.3	2
30	17828.8	11	81	0	0
31	38297.8	14	82	0	0
32	18192.5	9	83	0	0
33	10530.1	6	84	0	0
34	7558.6	3	85	2566.3	1
35	4277.4	3	86	0	0
36	3629.5	3	87	546.4	1
37	1911.4	2	88	2860.5	2
38	4625	3	89	1028.7	1
39	3562.3	4	90	10929.7	14
40	3880.9	5	91	0	0
41	4582.4	5	92	1424.8	1
42	2182.7	2	93	0	0
43	1306.8	2	94	0	0
44	4423.4	2	95	386.3	1
45	5404.9	5	96	0	0
46	5231.9	4	97	1115.2	1
47	9593.2	5	98	0	0
48	9442.2	3	99	620.5	3
49	0	0	100	0	0
50	1186.5	1			

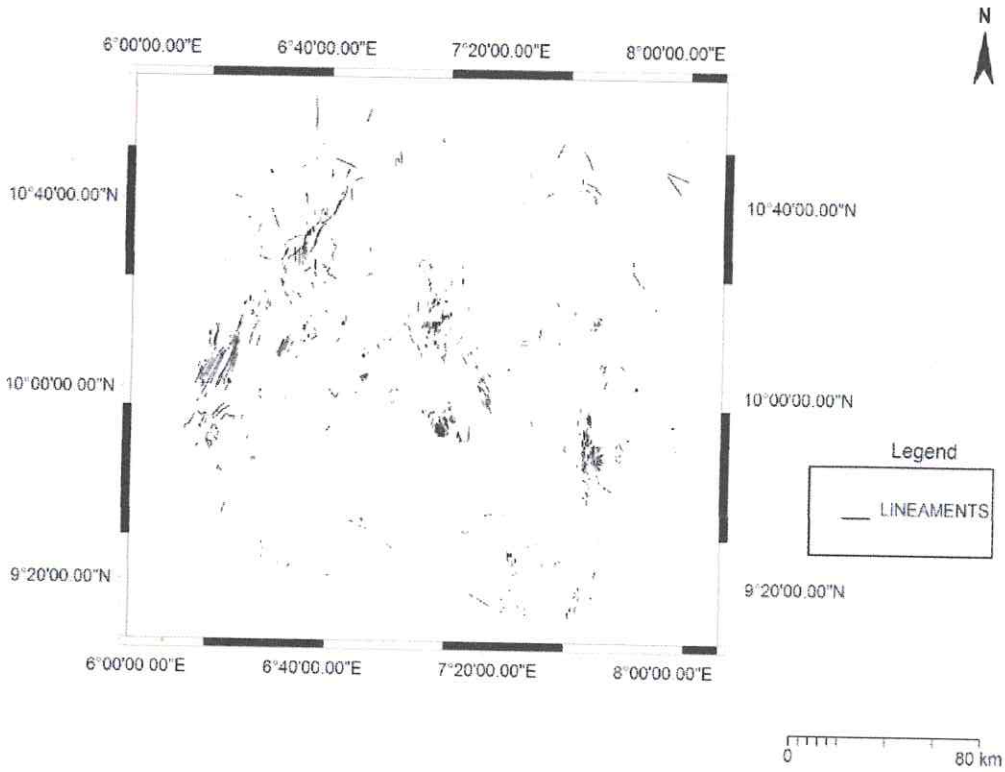


Fig. 12: Lineament Map

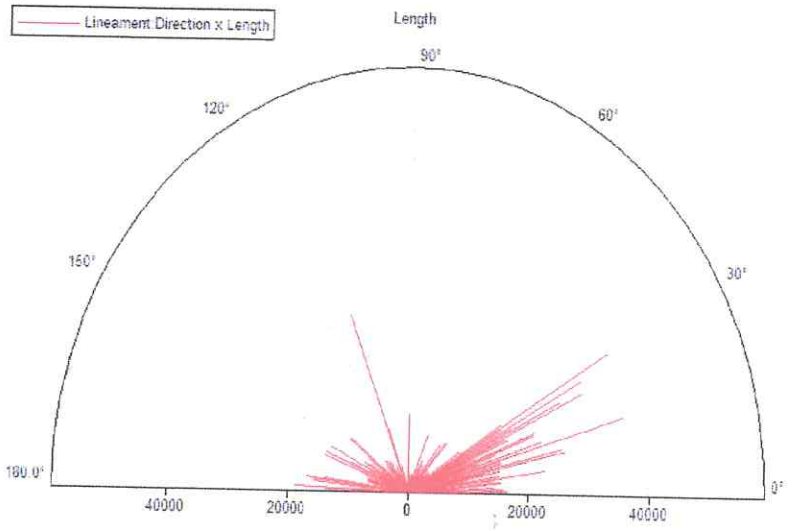


Fig. 13: Rosette diagram of lineament map.

The NNE – SSW trend of the lineaments implies that groundwater and potential solid mineral (primary gold mineralization) bearing structures trend NNE – SSW. The river traversing through contiguous highlands of resistant outcrops in Fig 14, reflect faulting. Part of the river course is a zone of weakness created by faulting, in line with Short (2007).

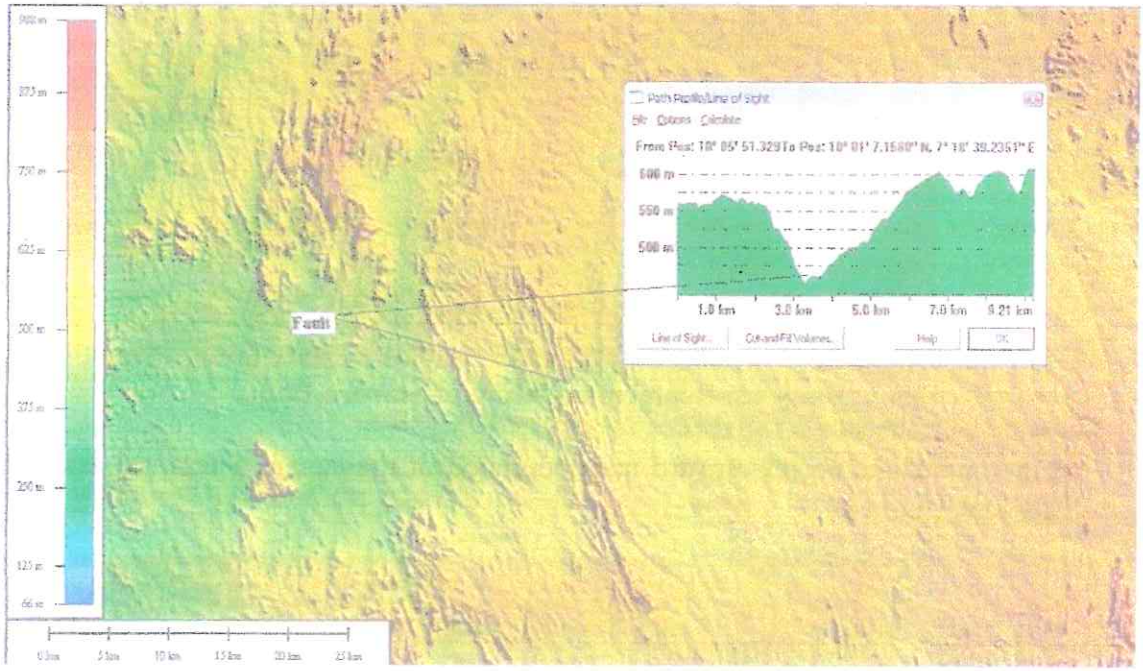


Fig 14. Faulting indicated by river courses through line of weakness

The faulting exists between Shiroro Dam and River Kaduna, on the NNE of the dam. The faults may be related to the transform faults constituting fracture zones in the Nigeria Continental Margin. Linear features observed on magnetic data across Nigeria, have been interpreted to be inland extension of NE-SW trending faults on Nigeria Continental margin (Ajakaiye et al, 1991; Udensi, 2000; Ako et al, 2004). Tectonic blasts that have become periodic in Paikoro Local Government Area of Minna (North Central Nigeria) may be related to periodic activation of these transform faults extension in the subsurface.

Fig. 15: shows a regional synform observed on the NNW of Shiroro Dam in Shiroro Local Government Area. The synform is regional, being 12km long and 5 km wide.

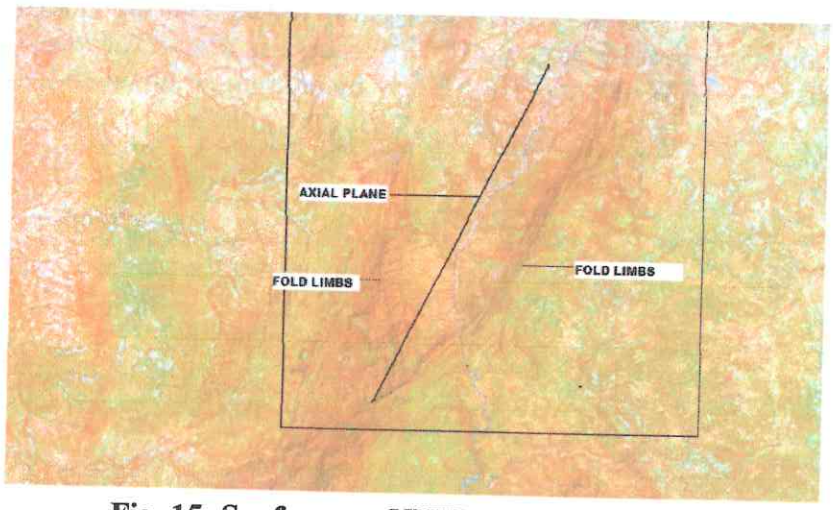


Fig. 15: Synform on NNW of Shiroro Dam

On the immediate northwestward neighbourhood of the dam is a regional antiform, 27km long (fig 16).

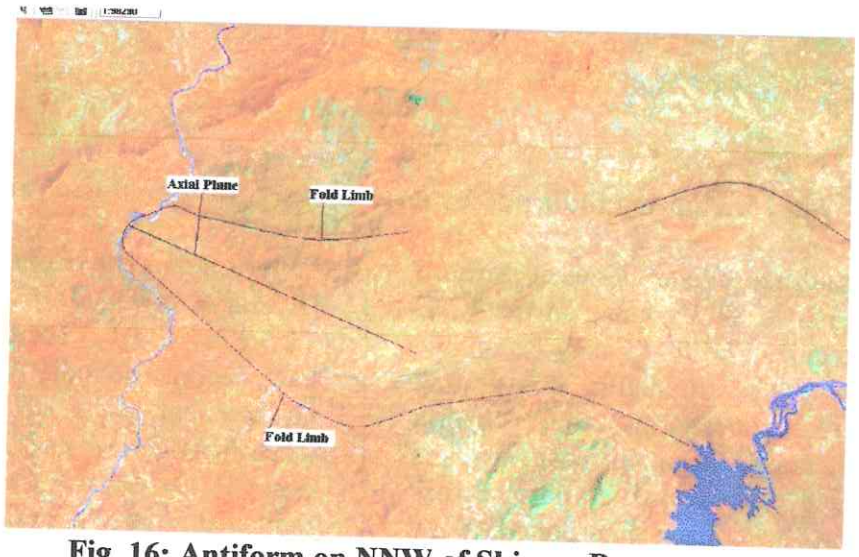


Fig. 16: Antiform on NNW of Shiroro Dam

The absence or paucity of lineaments in the locations of synform and antiform on NW of the study area reflects that the folds are constituted by plastic rocks. This agrees with schists and phyllites that are widespread in this area.

Exploration for primary gold mineralization and zones with adequate groundwater potential to meet urban needs should be guided by the lineament map and concentrated on the area defined by 6°20.00'E to 7°40.00'E and 9°20.00'N to 10' 40.00N.

Conclusion

Combination of ETM+ landsat and SRTM radar imageries has enabled the determination of rock types and structures on regional basis. The distribution pattern of the lineament has potential to guide groundwater exploitation for urban needs and exploration for primary gold mineralization.

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