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EXPLOITING THE POTENTIAL OF REMOTE SENSING FOR IMPROVING THE DELINEATION AND INTERPRETATION OF LINEAMENTS IN NORTH WESTERN KASHMIR

Sumira Nazir Zaz, Shakil Ahmad Romshoo and Irfan Rashid
Department of Geology & Geophysics, University of Kashmir, Srinagar-190006, J&K, India

ABSTRACT

In this study, an attempt has been made to map a high resolution lineament map of northwest Kashmir valley using remote sensing and GIS technology. In order to accomplish the study, Landsat ETM (2001) and the Landsat PAN (2001) images were used. Different edge enhancement techniques were applied on Landsat ETM to better identify the lineaments using 3x3 edge enhancement filter. The enhanced image was merged with the PAN image in order to differentiate between the artificial linear features such as roads, canals etc. and the lineaments. In all, 93 distinct linear features were identified and digitized their latitude, longitude and the direction was analyzed by rose diagram. By the analysis of these lineaments, it was found that 48 lineament are in NW-SE direction, 32 lineaments are in NE-SW direction, 7 lineaments are in N-S direction and 6 in E-W direction. From the existing tectonic map of the India, Main boundary Thrust Fault (MBT) was overlaid over the lineament map and it was found that the Fault (MBT) passes through the study area in the North western direction and the maximum lineaments are either parallel or perpendicular to the fault. The Drainage map of the study area, digitized from the Landsat ETM image, shows Trellis drainage pattern indicating that the drainage is controlled by different structural features. The mapping of these geological structures improves the existing knowledge about the distribution and direction of these structures in the Kashmir Himalayan region.

Key words: Neotectonic, Lineaments, remote sensing and GIS, Himalayas, MBT (Main Boundary Thrust), drainage pattern

INTRODUCTION

The Himalayas present a classic example of collision-type orogenic belt. It is formed as a result of the northward drift of Indian plate after its split from Gondwana, the consumption of intervening oceanic crust of the Neotethys and the collision with the Tibetan plate during the Eocene period, around 50 Ma ago. The collision was followed by the northward convergence of India against Tibet resulting in crustal shortening both on northern margin of India as well on the southern end of the Tibet (Chen and Molnar, 1977). The compression that was responsible for the Indian–Asian collision and consequent formation of Himalayan orogeny, though subdued, has not yet ceased (Nakata, 1989). In the Himalaya, numerous active faults and neotectonic features have been reported (Bilham, 2004; Valdiya, 1992) that have generated major and great earthquakes (Ambraseys and Douglae, 2004; Virdi and Philip, 2006). Recent evidence has shown that the Kashmir Himalayan region is tectonically very active. The tilting and elevation of the Pleistocene lake deposits of Kashmir Valley (Karewa series), containing recent plants and vertebrate remains to a height of 1500-1800 m, the dissection of river-terraces containing post –Tertiary mammalians to a depth of over 900m and over thrusting of older Himalayan rocks upon Pleistocene gravel and alluvium of the plains have been noted by various observers (Wadia, 1936).

Lineaments are one of the best geomorphic signatures that give us evidence of neotectonic activities taking place in an area, so accurate mapping of lineaments is very important. However, due to complex and rugged terrain of Himalayas conventional field based lineament mapping is a difficult task geomorphologically lineaments are defined as mappable simple or composite linear features whose parts are aligned in a rectilinear or slightly curvilinear and linear surface features such as valleys, ridges and boundaries of elevated areas, coastlines, boundaries of formation, fractures, faults, and joints (Lillesand and Kiefer, 1987; Peterson, 1980). The identification of lineaments is conditioned by the outcrop situation of the study area i.e. the presence of dense vegetation, alluvial deposits, scant volcanic ashes and human landscape transformation may prevent identification of lineaments.

In recent years, with the advent of satellite images having higher spectral and spatial resolution it is possible to recognize deformation structures in a better and more reliable way (Rao, 1986). Due to availability of remote sensing data particularly interferometry, hyperspectral data and GPS technology has revolutionized the study of topographic measurements, velocity measurements and mineral identification processes (Lillesand and Kiefer, 1987). GPS technique is highly accurate in plate movement measurements that can detect changes at a confidence level of millimeters (Kennedy, 1996).

One of the first clues of active tectonics is provided by drainage network, which is function of lithology, structure, climate and slope (Philip and Sah, 1999). Tectonic effects would obviously be manifested through changes in regional surface slope, which in turn would affect the drainage pattern (Virdi and Philip, 2006).

In the present study a portion of the Kashmir valley has been taken into account to prepare lineament map using satellite images and to analyze the direction of lineaments and find out the relation between lineaments and the drainage pattern of the area.

STUDY AREA

The study area lies towards the north west of Kashmir Valley from Wular Lake beyond towards Uri (Fig. 1). Its lies between 34°04′–34°50′N to 73°25′ to 75°50′E. It covers an area of about 500 sq km (Raza *et al.*, 1978).

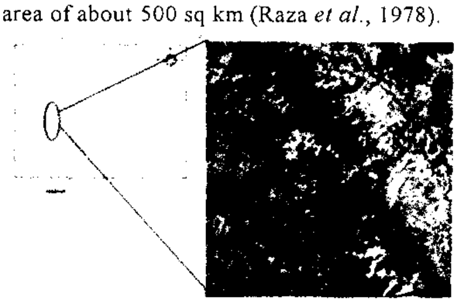


Fig-1: Study area

The study area is drained by Pohru, Kazinag and Jhelum and has very high relief, steep slopes and geologically consists of Murree formation. Murree series is variable in thickness, exceeding 2450m where it is fully developed. At the base of the series there is well marked conglomeratic bed with bone fragments and derived nummulites. The Murree outcrop is over 40km wide, where it crosses the Jhelum. On lithological grounds the series is divisible into lower and upper stages of variable thickness (Wadia, 1979).

In Uri Sector the most important tectonic feature is the Main Boundary thrust along which the pre Tertiary formations represented by rock of limestone and carboneous shale override the Muree Group of Rocks. The thrust zone is demarcated highly pulverized carboneous material (Prabhas *et al.*, 2006).

Data Sets used

In the present study following data sets from different sources were used:

Landsat ETM image (2001) with 30 meter resolution and LandSat ETM+PAN having 15meter resolution were used to map lineaments and Shuttle Radar Topographic Mission digital elevation model with 90 meter resolution Mission, existing tectonic map of Himalayas (Yeats *et al.*, 1984) and existing lineament map of Kashmir valley (Ganju and Khar, 1984) were used as secondary data sources.

MATERIAL AND METHODS

Landsat ETM image (2001) with 30 meter resolution and LandSat ETM+ panchromatic image (PAN) with 15 meter resolution were pre-processed and geometrically rectified. Different band combination were used in order to find the bands that are most suitable of mapping of different lineaments and finally FCC image [green (band 2), red (band 3) NIR (band 4)] (spatial resolution 30 m) of Landsat ETM 2001 were found best for mapping lineaments. Different edge enhancement techniques were used to preserve high frequency elements in the ETM image. The filter that was mainly found useful for identification lineaments was 3x3 edge enhancement filter as shown in Fig. 2. Although it enhanced the various natural linear features like rivers, discontinuous fractures, ridges etc but along with these lineaments the mountain peaks, roads, field boundaries were also enhanced. In order to differentiate between various artificial linear features like roads, railway tracks etc during digitization high-resolution Landsat ETM+ panchromatic image (spatial resolution 15m) was used to enhance the spatial resolution. Then lineaments were interpreted, mapped of standard color composite (FCC) image.

All possible lineaments were digitized on screen from the enhanced image. The latitude, longitude and direction of each lineament were stored during digitization for further statistical analysis. Direction of each lineament was plotted in a compass rose diagram. The resultant lineament map was compared with the existing lineament map of Kashmir valley (Ganju and Khar, 1984). The drainage pattern of the study area was digitized from the Landsat image and Ist and 2nd order drainage was analyzed using rose diagram and related with lineaments.

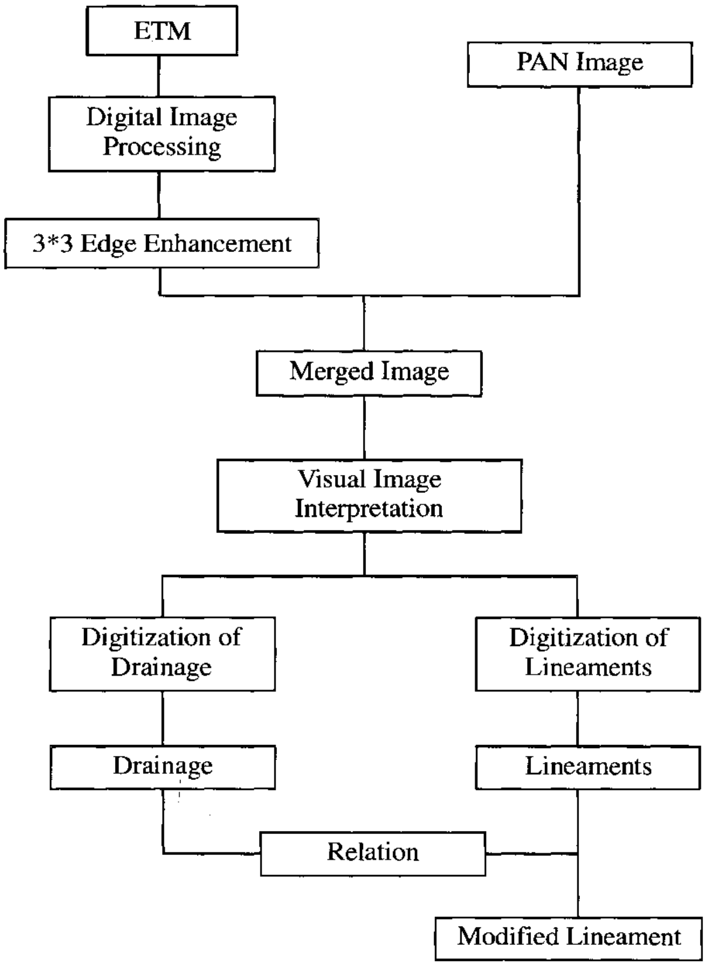


Fig. 2. Methodology flow chart

RESULTS AND DISCUSSION

Lineaments were mapped by the visual image interpretation of standard color composite (FCC) of Landsat ETM Image that was enhanced using 3x3 edge enhancement filter and then merged with the PAN image of 15meter resolution. The analysis of latitude longitude and direction of all possible Lineaments stored during digitization shows 92 linear features shown in Fig-3(a). Out of 92 lineaments 46 linear features lie in NW-SE direction, 33 lie in NE-SW direction, 7 lie in N-S direction and 7 lie in E-W direction shown in Fig-3(b). The analysis of rose diagram shows that maximum number of lineaments lies in NW-

SE direction. The direction of these lineaments was studied and three major lineaments found prominent in the image were Jhelum Lineament, Sopur Lineament and Uri lineament shown in Fig 3(a). These lineaments were then compared with the existing lineament map (Ganju and Khar, 1984) as shown in Fig-4 were only 73 lineaments were identified but the Jhelum lineaments, Sopur lineaments and Uri lineaments were also identified by the Gunju and Khar, 1984 as shown in Fig-4.

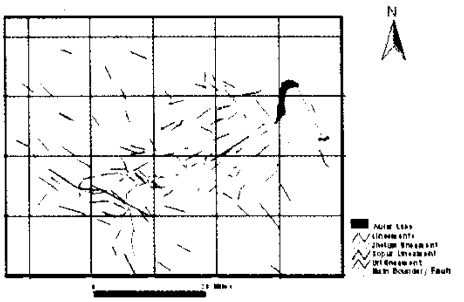


Fig. 3(a). Lineament map of northwest Kashmir valley

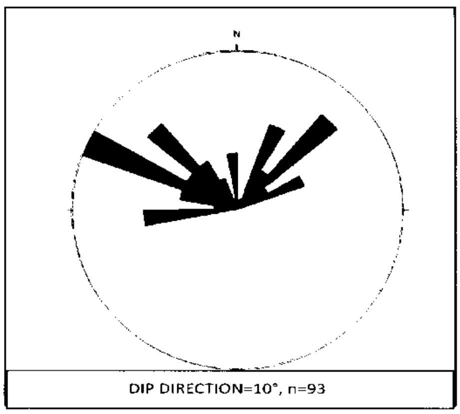


Fig. 3(b). Rose diagram of lineaments

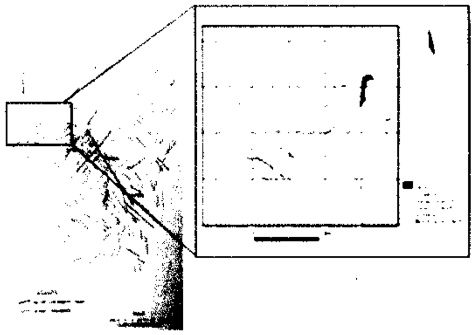


Fig. 4. Lineament map of northwest Kashmir valley (Modified after Ganju and Khar, 1984)

The existing tectonic map (Yeats *et al.*, 1984) of the study area was analyzed and it was found that Main Boundary Fault passes through the study area. By the overlay analysis it was found that most of the lineaments are either perpendicular or parallel to the MBT. It was found that the Uri lineament identified in the study area was actually a part of MBT as shown in Fig 3(a). The Drainage pattern of the study area was digitized from Landsat ETM image-2001 (Fig-5a, 5b) and it was found the drainage pattern of the area is mainly Trellis that is found in the areas that are structurally controlled (Seeber and Armbruster, 1979). The first and the second order streams were analyzed using rose diagram which revealed that the first order streams lie in NE-SW direction and the second order streams lie in NW-SE direction (Table 2 and 3). In order to study the relation between drainage and lineament, the lineaments were overlaid over the drainage map as shown in Fig-6, which revealed that some of important streams flow through these lineaments indicating that the drainage of the study area is structurally controlled (Seeber and Armbruster, 1979).

Table 1. Showing dip and strike direction of lineaments

Lineaments	Degrees	Direction strike	Lineaments	Degrees	Direction strike
1	50°	N50°W-S50°E	47	0°	N-S
2	28°	N28°W-S28°E	48	75°	N75°W-S75°E
3	50°	N50°W-S50°E	49	90°	E-W
4	35°	N35°W-S35°E	50	90°	E-W
5	40°	N40°W-S40°E	51	90°	E-W
6	55°	N55°W-S55°E	52	90°	E-W
7	40°	N40°W-S40°E	53	90°	E-W
8	60°	N60°W-S60°E	54	0°	N-S
9	60°	N60°W-S60°E	55	0°	N-S
10	40°	N40°W-S40°E	56	90°	E-W
11	35°	N35°W-S35°E	57	90°	E-W
12	25°	N25°W-S25°E	58	0°	N-S
13	40°	N40°W-S40°E	59	50°	N50°E-S50°W
14	45°	N45°W-S45°E	60	45°	N45°E-S50°W
15	45°	N45°W-S45°E	61	65°	N65°E-S65°W
16	65°	N65°W-S65°E	62	45°	N45°E-S45°W
17	25°	N25°W-S25°E	63	60°	N60°E-S60°W
18	15°	N15°W-S15°E	64	64°	N64°E-S64°W
19	65°	N65°W-S65°E	65	65°	N65°E-S65°W
20	60°	N60°W-S60°E	66	30°	N30°E-S30°W
21	60°	N60°W-S60°E	67	70°	N70°E-S70°W
22	50°	N50°W-S50°E	68	20°	N20°E-S20°W
23	60°	N60°W-S60°E	69	50°	N50°E-S50°W
24	65°	N65°W-S65°E	70	25°	N25°E-S25°W
25	80°	N80°W-S80°E	71	60°	N60°E-S60°W
26	60°	N60°W-S60°E	72	50°	N50°E-S50°W
27	70°	N70°W-S70°E	73	55°	N55°E-S55°W
28	60°	N60°W-S60°E	74	55°	N55°E-S55°W
29	60°	N60°W-S60°E	75	30°	N30°E-S30°W
30	65°	N65°W-S65°E	76	0°	N-S
31	60°	N60°W-S60°E	77	40°	N40°E-S40°W
32	60°	N60°W-S60°E	78	35°	N35°E -S35°W
33	40°	N40°W-S40°E	79	45°	N45°E-S45°W
34	45°	N45°W-S45°E	80	30°	N30°E-S30°W
35	35°	N35°W-S35°E	81	30°	N50°E-S50°W
36	40°	N40°W-S40°E	82	65°	N65°E-S65°W
37	45°	N45°W-S45°E	83	35°	N35°E-S35°W
38	55°	N55°W-S55°E	84	60°	N60°E-S60°W
39	70°	N70°W-S70°E	85	50°	N50°E-S50°W
40	30°	N30°W-S30°E	86	50°	N50°E-S50°W
41	80°	N80°W-S80°E	87	55°	N55°E-S55°W
42	70°	N70°W-S70°E	88	20°	N20°E-S20°W
43	30°	N30°W-S30°E	89	30°	N30°E-S30°W
44	75°	N75°W-S75°E	90	40°	N40°E-S40°W
45	0°	N-S	91	65°	N65°E-S65°W
46	0°	N-S	92	50°	N50°W-S50°E

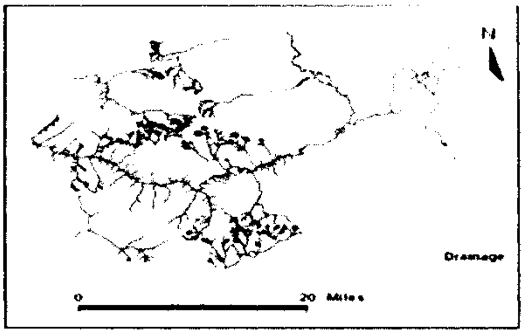
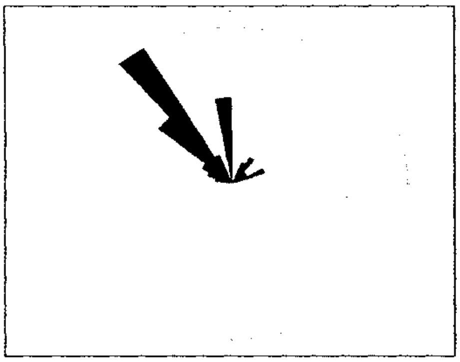
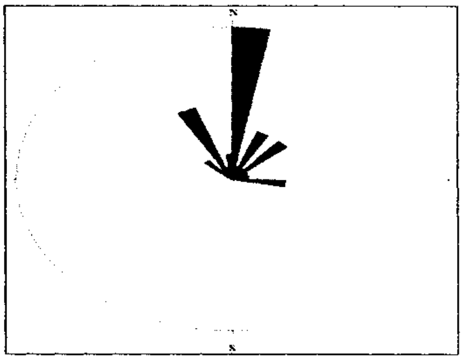


Fig. 5(a). Drainage map of Study area
Source: Landsat ETM, 2001





DIP DIRECTION = 10°, n = 69 DIP DIRECTION = 10, n = 36

Fig. 5(b). Dip and strike directions of first and second order drainage

Table 2. Showing the dip and strike direction of first order drainage

Drainage No.	Direction	Drainage No.	Direction	Drainage No.	Direction
1	N60°E	24	N75°E	47	N60°E
2	N40°E	25	N35°E	48	N30°E
3	N20°E	26	N40°E	49	N30°E
4	N30°E	27	N-S	50	N35°E
5	N60°E	28	N50°E	51	N-S
6	N20°E	29	N45°E	52	N60°E
7	N20°E	30	N30°E	53	N-S
8	N20°E	31	N50°W	54	N45°W
9	N50°E	32	N30°W	55	N35°W
10	N50°E	33	N50°W	56	N50°W
11	N30°E	34	N60°W	57	N60°W
12	N45°E	35	N60°W	58	N40°W

Table 2 Contd....

Table 2 Contd....

13	N50°E	36	N60°W	59	N60°W
14	N50°E	37	N60°W	60	N60°W
15	N60°E	38	N60°W	61	N45°W
16	N40°E	39	N60°W	62	N30°W
17	N20°W	40	N60°W	63	N30°W
18	N-S	41	N60°W	64	N30°W
19	N-S	42	N60°W	65	N35°W
20	N-S	43	N-S	66	N40°W
21	N30°W	44	N35°W	67	N30°W
22	N60°W	45	N40°W	68	N65°W
23	N70°E	46	N45°W	69	N45°W

Table 3. Showing the dip and strike direction of second order drainage

Drainage No.	Direction	Drainage No.	Direction	Drainage No.	Direction
1	N60°W	13	N50°W	25	N20°E
2	E-W	14	N-S	26	N40°E
3	N80°W	15	N30°E	27	N-S
4	E-W	16	N-S	28	N10°E
5	E-W	17	N50°E	29	N40°E
6	N45°W	18	N-S	30	N60°E
7	N60°W	19	N40°E	31	N20°E
8	N40°W	20	N-S	32	N-S
9	N65°W	21	N-S	33	N40°E
10	N60°W	22	N-S	34	N70°E
11	N60°W	23	N-S	35	N-S
12	N80°W	24	N-S	36	N-S

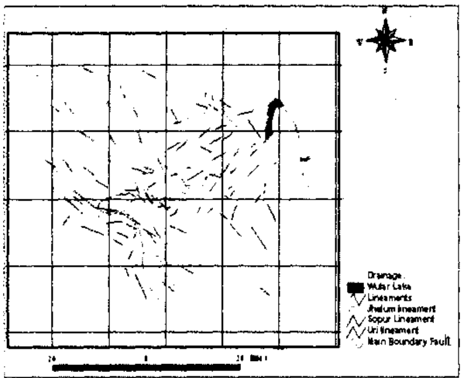


Fig.6. Showing relationship between drainage and lineaments

CONCLUSIONS

In the present study, an attempt was made to map different lineaments from Landsat ETM satellite image using numerous edges enhancement filters. The edge detection filters assigned maximum pixel values along the lineaments and then lineaments were mapped by the visual image interpretation of standard color composite (FCC) image and features such as lithological dislocation, fault traces, truncation of outcrops, alignment of streams etc were delineated. The edges reflected the micro lineament pattern and 93 lineaments were mapped. Among these lineaments, three most prominent lineament are Jhelum lineament, Sopur Lineament and Uri lineament. Direction, latitude and longitude of these lineaments was studied and analyzed in the rose diagram and maximum number of lineaments and the streams were found to lie in the North western direction. Out of all the features identified, 47 linear features lie in NW-SE direction, 34 lie in NE-SW direction, 5 lie in the N-S direction and 8 lie in the E-W direction. From the existing regional tectonic map of the valley (Yeast *et al.*, 1992) Main boundary Fault passing through the area was digitized and it was found that this major fault passes through the area in the north western direction. It confirms that the micro lineaments and the drainage pattern in the area is strongly controlled by the regional tectonic setup of the valley.

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