Journal of Nepal Geological Society
Vol. 1, No. 2., 1981. 10-17

LANDSAT IMAGERIES IN THE STUDY OF PLANAR SURFACES AND LINEAMENTS IN GARHWAL HIMALAYA, INDIA

C. PRASAD, A. K. SHANDILYA

Department of Geology, Garhwal University, Srinagar, Garhwal, India.

V. K. VERMA

Department of Geology, University of Delhi, Delhi, India.

सारांश

गढवाल हिमालयमा पर्ने अलक नन्दा, मन्दाकिनी र भिलन गङ्गा नदीको जलाधार समुह क्षेत्रको अनुचर प्रतिमावली (Landsat imagery) तथा स्थलाकृति नक्साहरू (Topographic maps) को मिमाँसा र स्थल निरिक्षणको आधारमा आकारौय्त्तिक बनावट (Morphological feature) को पहिचान र अध्ययन गरी विभिन्न सम सतह र रेखीय आकार (Planar surfaces and Lineaments) को रेखाङ्कन गरिएको छ।

यस अध्ययनबाट के देखिन्छ भने मुख्य रेखीय आकारहरू आलिङ्गन अक्ष (Fold axes) उन्मुख पात भ्रंश कटिबन्ध (Fault zones) या भंजन कटिवन्ध (Fracture zone) हुन। मुख्य मध्य प्रघात (Main Central Thrust), अलकनन्दा भ्रंश, श्रीनगर (उत्तर अलमोडा) प्रघात र गढवाल प्रघात जस्ता प्रमुख भ्रंश कटिवन्धहरु वायव्य-आग्नेय (NW-SE) तथा पूर्व-पश्चिम उन्मुख रेखीय आकारहरु द्वारा प्रतिनिधित्व भएका छन् भने मन्दाकिनी र भिलनगङ्गा भंजन कटिवन्धहरु उत्तर इशान-दक्षिण नैऋत्य (NNE-SSW) तथा उत्तर-दक्षिण रेखीय आकारहरु द्वारा प्रतिनिधित्व भएका छन्।

तिन स्पष्ट सम सतहका तहहरू पहिचान गरिएका छन्। शिर्षस्थ र मध्य सतहहरू भ्रंश कटिवन्धको सामुन्ने राखेर हेर्दा तिनीहरूको औसत उचाई मा फेर वदल भएको स्पष्ट देखिन्छ, जस्ले यी भ्रंश कटिवन्धहरू हाल सालै पूनः क्रियाशील भएका हुन भन्ने दर्शाउंछ। यस आधारमा मन्दाकिनी भंजन कटिवन्ध हाल सम्म पहिचान नगरिएको एउटा पूनः क्रियाशील जग भ्रंश (Basement fault) जस्तो देखिन्छ।

ABSTRACT

Morphological features are identified and studied on the basis of the interpretations of landsat imageries and topographic maps, aided by field checks in the study area comprising the drainage network of Alaknanda, Mandakini, Bhilanganga rivers in Garhwal Himalaya. Various planar surfaces and lineaments are delineated.

The studies show that the major lineaments oriented in NNE–SSW, E–W, NW–SE, ENE–WSW, NE–SW, and N–S directions are either fault zones or the zones of fracturing along the major fold axes. The major fault zones like the Main Central Thrust, Alaknanda fault, Srinagar (North Almora) thrust and Garhwal thrust are represented by NW–SE and E–W trending lineaments, while Mandakini and Bhilanganga zones of fracturing are represented by the NNE–SSW and N–S lineaments.

Three distinct levels of planar surfaces have been identified. The summit and middle surfaces exhibit distinct variations in their mean altitudes when placed on the opposite sides of fault zones, which indicate some recent reactivation of these fault zones. On this basis, the Mandakini fracture zone appears to be a reactivated basement fault, which has not been identified so far.

INTRODUCTION

Various morphological features were analysed for the identification of planar surfaces and lineament zones of tectonic disturbances, generally followed by rivers and their tributaries (Vaidyanandhan, 1966).

The study area bounded between north latitudes 30° and 30° 30' and east longitudes 75° 10' and 78° 40' constitutes a part of Lesser Himalaya in Garhwal, Uttar Pradesh, drained by the river systems of Alakananda, Mandakini, Bhilanganga Nayar etc, generally occupying their antecedent gorges in narrow and deep valleys through lofty and rugged hill ranges (Fig. 1). Its northern part has low precipitation and winter snow fall, with weak chemical weathering, moderate frost action and strong mass-movement, characterising a periglacial zone (Peltier, 1950) whereas, the southern part is a phreatic zone (Penck, 1973), with high and regular precipitation with rivers maintaining a fairly constant flow.

GEOLOGICAL FRAME WORK

The structure and stratigraphy of this area have been described by several authors: Heim & Gansser (1939), Kumar & Agarwal (1975), Sharma (1977) and Fuchs & Sinha (1978). Their results are summarised in Figure 2 and Table 1.

Table 1 The general lithostratigraphy of the Lesser Garhwal Himalaya.

Age	Formations	Lithological characters
Quaternary	River terraces	Sand, silt, clay and gravel beds.
Neogene	Siwaliks	Sand, clay and conglomerate.
Paleogene	Dagshai, Subathu	Sandstones, limestones and shales.
Mesozoic	Tals, Krols	Quartzites, shales, limestones, slates.
Upper Paleozoic	Blainis (Mandhalis)	Boulder beds, slates.
Lower Paleozoic	Jaunsars	Quartzites, phyllites.
Pre-Cambrian	Chails, Simla Slates	Phyllites, schists, quartzites.

The following is the brief description of the major geological units of the study area:

Central Crystallines: Lying in the northern part is the zone with gneisses and schists along with granitic rocks. The Main Central Thrust (Heim & Gansser, 1939) with east-west trend and steeply dipping to the north, forms the southern boundary.

Chail Nappes: This unit lying south of the Central Crystallines is discussed by Fuchs & Sinha (1978). These are characterised by mainly clastic metasediments such as phyllite and quartzite with basic metavolcanic intercalations. These nappes have been separated by some fault zones like Kande, Alaknanda etc., described by Kumar & Agarwal (1975), and by Srinagar thrust. All these faults have a general E-W or NW-SE trend.

Dudatoli Syncline: Discussed by Sharma (1977), the Dudatoli syncline is bounded by North Almora and South Almora thrusts, and is the extension of Almora-Lohaghat synclinorium of the Kumaon Himalaya. This may be considered as a detached outlier of the Central Crystallines.

Para-autocthhonous unit : Also called Krol belt, this unit is described by Fuchs & Sinha (1978). It is bounded towards north by the Garhwal thrust and in the south by Krol thrust. This unit is composed of Mesozoic and Upper Paleozoic rocks with some isolated patches of Paleogene sediments.

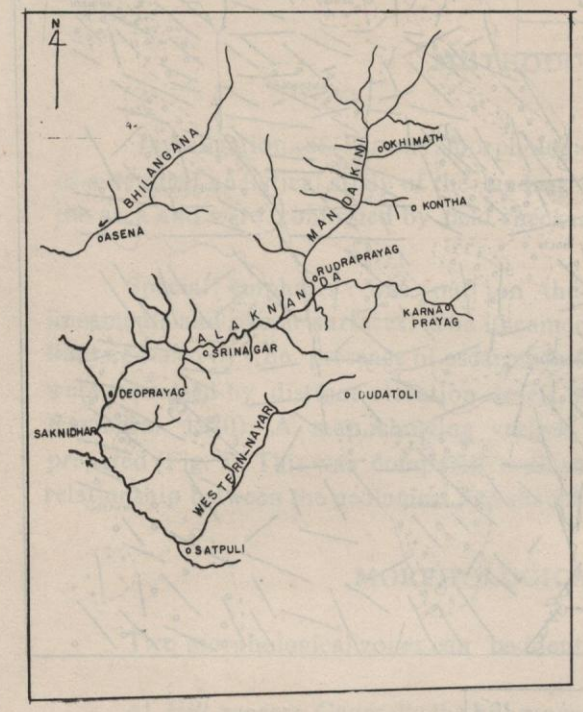


Fig. 1 Location map

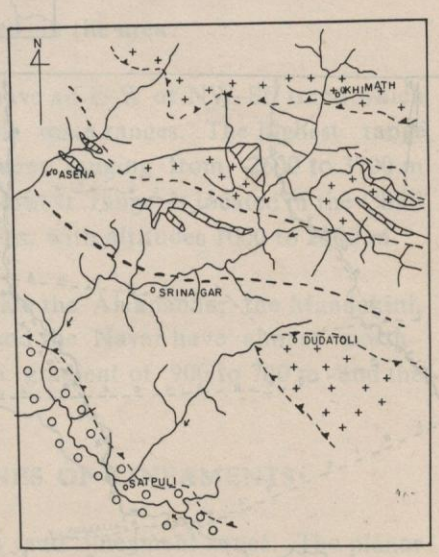
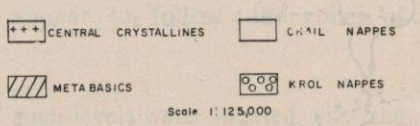


Fig. 2 Geological map (after Fuchs & Sinha, 1978)



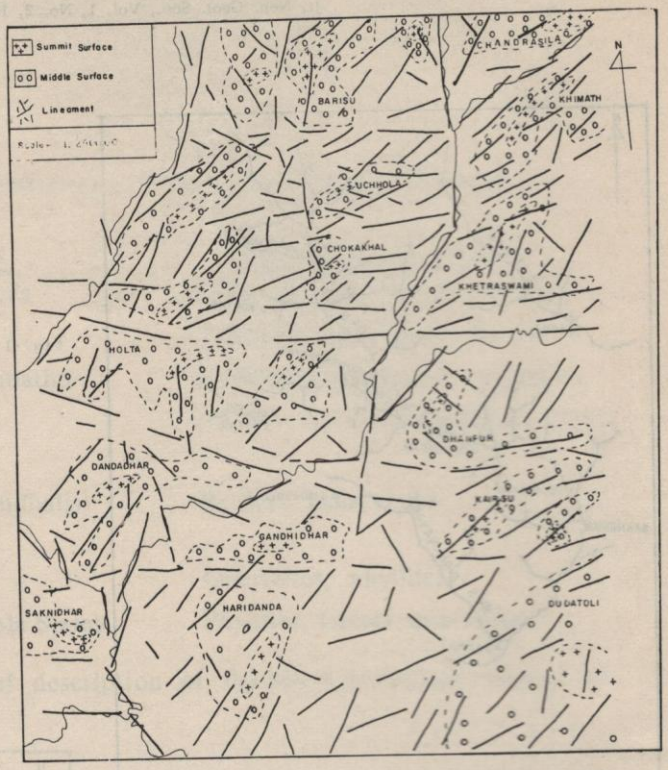


Fig. 3 Lineament and Planar surfaces

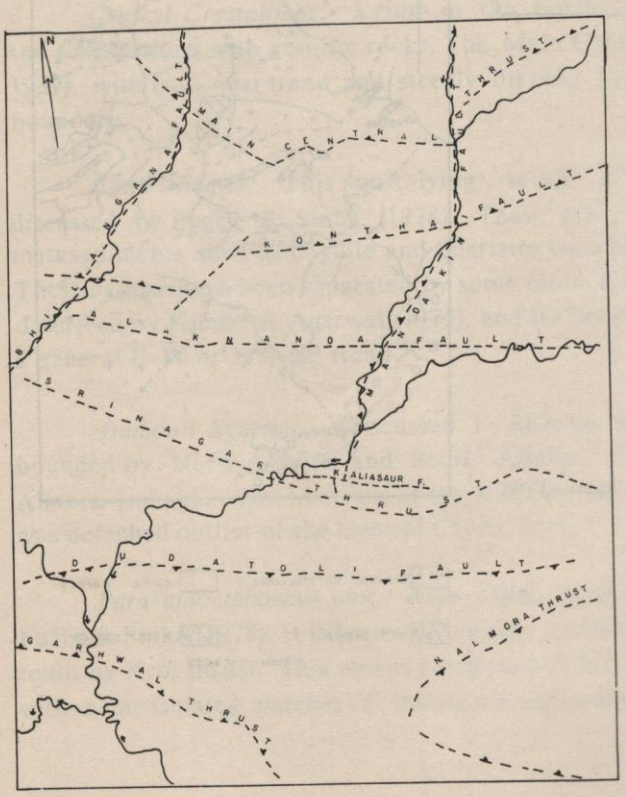


Fig. 4 Tectonic map of Garhwal Himalaya based on landsat imagery

Scale-1:250,000

METHODOLOGY

Investigation of various morphological features was made on the basis of a detailed analytical study of the landsat imagery aided by topographic map of the area and were confirmed by field checks.

Special emphasis was put on the identification of various zones of lineaments and planar surfaces. The lineament zones were indicated by drainage lines and also by the presence of escarpments (Sharma, 1977). The planar surfaces were expressed by distinct elevation levels that are flat or nearly flat (Bakliwal & Ravindra, 1980). A map showing various lineaments and planar surfaces was prepared (Fig. 3). This was compared with the geological map of the area, and the relationship between the geological and morphological features was determined.

MORPHOLOGICAL ZONES

Two morphological zones can be identified in the area:

a) Hill ranges: Generally the hill ranges have an E–W or NW–SE trend which is parallel to the tectonic alignment. There are six main ranges. The highest range is located in the Central Crystallines with altitudes ranging from 2600 to 3700 m and the bedrocks as gneisses and schists. The lowest range is located in the Chail Nappe zone having mainly phyllites and quartzites, with altitudes 1000 to 2300 m.

b) River valleys; The main river valleys are the Alaknanda, the Mandakini, the Bhilangana and the Nayar. The Bhilangana and the Nayar have almost north–south trend. The Mandakini has the maximum gradient of 900 to 700 m and the Nayar has the minimum (600–500 m).

PLANAR SURFACES AND ZONES OF LINEAMENTS

Figure 3 depicts various planar surfaces and lineament zones. The planar surfaces were generally found at the top and on the sides of the hill ranges, whereas most of the river valleys and their tributaries appear to follow the zones of lineaments.

a) Planar surfaces: In general, only two such levels were located viz. the unconsumed summits on the top of hill ranges, and the erosional surfaces on the sides of the ranges as middle surfaces.

Table 2 gives various planar surfaces along with their mean altitudes and the type of bedrocks.

Table 2 Planar surfaces of the Lesser Garhwal Himalaya

Hill ranges	Unconsumed summits (altitude in metres)	Middle surfaces (altitude in metres)	Type of bed rocks
Bansuchandrasila	3000–3250	2600–2850	Gneisses, schists
Unchola–Okhimath	2100–2700	1600–2500	Phyllites, schists
Chorka Khal Khetraswami	2300–3000	1750–2350	Gneisses and schists
Holta Dhanpur	2600–2800	1500–2500	Dolomites, quartzites
Danda Dhar Khirsu	1800–2300	1000–1700	Phyllites, quartzites
Sakini Dhar Dudatoli	2000–2400	1200–1800	Gneisses, schists

Table 2 clearly shows that all the planar surfaces are located at different altitudes. The nature of bedrocks also play some role in these differences, but in the case of the presence of similar bedrocks the difference in altitudes is remarkable.

b) Zones of lineaments: Table 3 gives the major lineament zones and their generel trends, along with the mean altitudes of the unconsumed summits on both sides.

It shows that the planar surfaces along all these lineament zones have different heights. It may be attributed to differential uplifts, and all such lineaments may be fault zones. As most of these lineaments with an exception of the Bhilangana–Kakragad, are nearly straight, such faults appear to be either vertical or high angled.

Table 3 Lineament zones of Lower Garhwal Himalaya

Lineament zones	General trends	Mean altitudes in metres of unconsumed summits on both sides
Bhilangana–Kakragad	NNW–SSE E–W and NE–SW	920 — 765
Kontha-Chandrapuri	ENE–WSW	765 — 825
Mandakini	N–S and NNE--SSW	900 — 780
Bhilangana	NNE--SSW and NE--SW	810 — –
Gaucher--Rajkhal	E--W and WNW--ESE	810 — 750
Dhanpur--Silkakhal	NW--SE and E--W	780 — 600
Rudraprayag--Khirsu	N--S	690 — 540
Khirsu--Gandhidhar	ENE--WSW	600 — 660
Sakni Dhar	NW--SE	660 — 480
Dudatoli	WNW--ESE	720 — 600

DISCUSSIONS

Kumar & Agarwal (1975) have described three main phases of tectonic activity in this area. According to them (i) the first phase is characterised by major faults and fold axes with NW–SE trends (ii) second phase by the fold axes of NE--SW trend and (iii) the third phase with fault and fracture zones again with NW--SE trend. The lineaments also appear to follow these three trends with exception to the Khirsu--Gandhidhar. Therefore, these lineament zones may possibly represent four tectonic phases.

The Bhilangana--Kakragad lineament appears to correspond to the Main Central Thrust, as the gneisses and schists of the Central Crystallines extend to this level. A significant difference in the planar surfaces on two side of about 500 metres indicates some possible uplifts during recent times. Thc Kontha-Chandrapuri lineament has different bedrocks on the two sides with remarkable differences in their planation surfaces. This may be the extension of the Kande fault, recorded by Kumar & Agarwal (1975). A significant series of landslides along this alignment further supports this contention (Prasad, 1979). The Mandakini lineament zone may represent the Mandakini fault with about 400 metres difference on the planation surfaces on both sides, although with similar bedrocks. The Rudraprayag-

Khirsu lineament may be the southward extension of this fault. Similarly the Bhilangana lineament may also represent a fault zone. The Main Central Thrust appears to have been affected by the Mandakini fault. Therefore, whereas the Main Central Thrust represents the first phase, the Mandakini fault would represent the second phase of tectonic activity. Similarly, the Bhilangana fault may also belong to the second phase.

The Gaucher–Rajkhal lineament may correspond to the Alaknanda fault of Kumar & Agarwal (1975). This appears to have displaced the Mandakini fault, and therefore it along with Kontha fault may belong to the third phase of tectonic activity.

The Dhanpur–Silkakhal lineament may correspond to the Srinagar thrust (Fuchs & Sinha, 1978). But its near straight alignment favours a high angle dip. A branch of this may be the Kaliasaur shear zone (Rupke, 1974). The Khirsu–Gandhidhar lineament may represent the Dudatoli synlinal axis (Sharma, 1977). Along this some displacement as indicated by the planar surfaces has taken place. A different trend of this suggests that it may represent the fourth phase of tectonic activity. The Dudatoli lineament may be North Almora thrust (fault). The Sakinidhar lineament may correspond to the Garhwal thrust (Fuchs & Sinha, 1978). This may also be a fault belonging to the third phase. All these tectonic alignments may be reactivated basement fault (Rupke, 1974) rather than thrusts.

Based upon the above discussion a general tectonic map has been prepared (Fig. 4).

CONCLUSIONS

i) All the major morphological features in this area correspond to the tectonic alignments and rock foundations.

ii) All the major lineaments are faults that may have been recently reactivated.

iii) Most of the lineaments represents the three phases of tectonic activity, although a fourth phase may also be there.

iv) Four new faults viz. Kontha, Mandakini, Bhilangana and Dudatoli are deciphered on the basis of the differences in the planar surfaces.

REFERENCES

Bakliwal P. C. and Ravindra, R., 1980. Planar surfaces in North-Eastern Rajasthan. Proc. Seminar on Remote sensing techniques, Dehra Dun, 32–33.

Cunningham, F. F. and Griba, W., 1973. A model of slope developmentN.. Geomorph. N. P., 17 (1), 43–77.

Fuchs, G. and Sinha, A. K., 1978. The tectonics of Garhwal–Kumaon Lesser Himalaya. Janrb. Geol. 121 (2), 219–241.

Heim, A. and Gansser, A., 1939. Central Himalaya: geological observations of the Swiss expedition. Mem. Soc. Helv. Sci. natt. 73 (1), 1–245.

Kumar, G. and Agarwal, N. C., 1975. Geology of Srinagar–Nandprayag area (Alaknanda valley), Kumaon Himalaya. Him. Geol., 5, 29–59.

Peltier, L. C., 1950. The geographic cycle in periglacial regions as related to climatic geomorphology. Ann. Assoc. Amer. Geog., 40. 219–236.

Penck, A,, 1973. Attempt at a classification of climate on a physiographic basis. Climatic geomorphology, Mac Millan & Co. 51–60.

Prasad, C., 1979. Landslides in Kontha area, Garhwal. Report submitted to U. P. Govt. India (unpublished).

Rupke, J., 1974. Stratigraphic and structural evolution of the Kumaon Lesser Himalaya. Sed. Geol. 11 (2,4).

Sharma, R. P., 1977. The role of Multi spectral imagery in the elucidation of tectonic frame work and economic potentials of Kumaon and Simla Himalaya. Him. Geol. 7, 77–99.

Vaidyanadhan, R., 1966. Effects of uplift and structures on the drainage in the southern part of Cuddapah basin. Jr. Geol. Soc. India, 3, 84–85.