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A Lithological and Structural Study in Parts of Nainital and Almora Districts of Uttarakhand

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Abstract:
The study area which comes under the geodynamically sensitive Kumaun Himalayan region has frequently witnessed the landslide disasters during the past half a century. The entire area is rocked by some neotectonic activities and earthquakes. The Nainital and Almora district lying in this region is very fragile due to tectonically folded, faulted and crumpled rock formation of various thrust sheets. The area is subjected to sporadic earthquake tremors which plays a significant role in the configuration and topography of the region. In this paper an attempt has been made to analyse and identify the lithological structure of the area which is responsible for the mass slope failures in the concern area.

Key Words: *lithology, slope, landslide*

1. Introduction

The Lesser Himalaya is considered to be a tectonic zone that lies between the Main Boundary Thrust (MBT) to the south and the Main Central Thrust (MCT) to the north. Two principal tectonic elements are recognized in the Lesser Himalayan Zone of the Kumaun Himalaya,

a) The rock formations of the Lesser Himalayan Basin,
b) The klippen units of the crystalline thrust sheets.

The Almora and Nainital area lies in the vicinity of the seismotectonically active Main Boundary Thrust(MBT) in the south. The area has been traverse by number of thrust and faults and as a result the slopes have become vulnerable to landslide and erosion.

2. Objectives

The main objective is to study the rock structure of the area to understand the overall geological settings of the terrain triggering mass movement to an alarming position.

3. Study Area

The area lying between 29 15 N to 29 35N and longitude 79 25E to 79 40E, covering about 89000ha(890sq km) area of Nainital and Almora districts of Uttarakhand.

4. Methodology

As the study area lies in the mountainous region, for more accuracy some remote sensing satellite data has been used for making of thematic maps. PAN data, IRS-1C/1D and LISS –III data is visually interpreted on the respective theme. Survey of India topographical maps on 1:50000 scales were enlarged upto 1:55618 scale and used it for base map preparation. Digitization is done on geomaticasoftware. Ground truthing has also been done in the study area.

5. Theme Analysis

The study area is having four distinct lithological units, characterized by distinct lithological compositions which are easily identifiable. Youngest of these is the autochthonous unit of the Siwalik super group that is thrusted over successively by Krol, Ramgarh and Almoranappes. The Almoranappe made up of medium grade metamorphics intruded by granitic suite is the oldest allochthonous unit and thrust over the RamgarhNappe along the South Almora Thrust (SAT). The Ramgarhnappe is thrusted over along the Ramgarh thrust, the krolnappe which in turn is thrusted over the Siwaliks along the Main Boundary Thrust (MBT).Pressed strongly by the northward underthrusting, Indian plate weighed down by a huge pile of metamorphics and granites of the Ramgarh and Almoranappes, the krolnappe is the tight synclinorium, splited up both longtudinally and transversely by a multiplicity of faults. Important amongst the transverse faults is the Nainital-Bagargaon-Shyamdhar-Kwetani faults series, which extends from Jeolikot through Naini Lake to Kunjakharak and cuts the Nainitalsinclinorium into two dissimilar parts. The

NainaSherkaDanda Range was uplifted along this fault relative to the Ayarpatta -Deopatta Range in the south. The whole belt of Nainital fault is cut by a number of N-S and NE/ENE/SW/WSW trending faults. Along one of the N-S trending faults, the Nihal stream, and west of Nainital has curved out its deep straight gorge. Another such tear fault is the Giwalikhet fault that extends from Jamira to Nainital golf Course, along the Saulia Gad.

Another important transverse fault that has displaced the MBT by less than half a kilometer at the confluence of Balia-Kuriya. The Kuria fault branches off half a kilometer west of Bhumiyadhar. One branch of it extends upto the east of Pangot and the other extends through Dauniakhan, Jakh, east of Churani and ultimately merges into the Nainital-Bagargaon-Shyamdhar-Kwetani fault series. Two N-S trending faults branch off on the eastern side from the Kuria faults. The extraordinary wide Tirchakhet valley filled with landslide debris has been curved in the fracture zone and lake Sat Tal and Puna Tal are delimited to the west by the fault that has caused subsidence of the terrain to the east. Two more N-S trending faults east of Kuriya fault have further dismembered the area north of MBT into two blocks. One of these extends from the east of Amritpur, through Sundi, KhairolauptoBhimtal and another extends from the west of Kula upto northeast of Jangliya. At their southern end, both of these faults merge into the MBT and streams flowing through them have curved deep gorges.Most notable amongst the N-S trending faults is the Garampani faults. This dextral tear fault is traceable from the Chorsa spur in the south through the valley of Khairna stream, east of Bhujan up to west of Bamsyan. The fault valley all through is characterized by triangular fault facets and recurrent landslides. The dextral displacement of Ramgarhquartzs porphyry along the Garampani fault is of the order of 1.5 Km.As mentioned earlier, the rocks of the study area belong to the four distinct tectonic units. The tectonostratigraphic setup of the study area is summarized as foll.

Almora Group		
	South Almora Thrust	
Ramgarh Group		
	Ramgarh Thrust	
Mussoorie Group		
		Tal Formation
		Krol Formation
		Blaini Formation
	Sharp Contact	
Jaunsar Group	Nagthat formation	
	Salari Thrust	
Amritpur Granite		
	Main Boundary Thrust	
Siwalik Group		

Table 1: Tectonosratigraphic set up of the study area (After Valdia, 1980)

The oldest rocks exposed in the study area, thus, belong to the Almora Group. Three distinct lithological suits can easily be identified within the Almora Group. These are as follows:

1. Crystallines and Schists
2. Quartzite
3. Granite and Augen gneisses

The rocks of the Almora group tectonically lie over the Ramgarh group along the SAT (South Almora thrust). Three distinct lithological sites can easily be identified within the Ramgarh Group also. These are:

1. Profoundly mylonitized chlorite quartz porphyry
2. White and purple sericitic medium grained quartzite interbedded with grey green and silvery sericiteschist and chocolate brown, limonitic phylite
3. Carbonaceous and locally pyretic phyllites and slates altering with blue green banded marmorized limestone

The Ramgarh Group is thrusted over the KrolNappe along the Ramgarh Thrust. It constitutes the oldest sedimentary succession in the Krol nape followed up by Blaini, Krol and Tal formations. The oldest Nagthat and Blaini formations have been truncated in the south by the MBT so that the Krols are juxtaposed with the Siwaliks.The sedimentary succession of the Krolnappe, thus begins with the Nagthat formation, which comprises purple, maroon, pink, fawn, white and green locally pebbly, quartzarenite and interbedded with subordinate purple and olive green slate. The quartzarenite and interbedde slates of the Nagthat Formation have been designated as the BhawaliQuartzites by Valdia. The BhawaliQuartzites are associated with penecontemporaneous basalts and tuffites of the BhimtalVolcanics.

The Nagthat formation is followed up, with a sharp contact, by the Blaini formation. The lowermost part of the Blaini formation that is the Bhumiyadhar Member consists of greenish brown to grey lithicwacke and greywacke interbedded with and laterally grading into ubiquitously limonite stained light brown to ash grey slates and siltstones. In the Kosi valley, the Bhumiyadhar member merges laterally with the Betalghat member which consists of rhythmic alterations of carbonaceous phyllite/slate and thinly bedded blue grey to black marmorized limestone. The Bhumiyadhar Member is transitionally overlain by a thick succession of white, pink, purple and light green, locally pebbly, quartzarenite and quartzwackeinterbedded with subordinate purple and green slates and siltstones belonging to the Lariakantha Member. Overlying the Lariakantha Quartzite in a succession of diamicite, it is intimately associated with purple slate, calcareous sandstone and deep pink siliceous-dolomitic limestone. This unit has been named as the Pangot member by Valdia. The purple slates associated with the diamicitites of the Pangot Member give way to the ash grey, dark grey or black shales of the Kailakhan Slates or Infra Krol. These shales are characterized by decolorization rings and limonite staining.

The grey carboneous slates of the Kailakhan Member are followed up by calcareous slates and marls, with intercalations of argillaceous limestone, of the lower krol. The lower krol is transitionally overlain by dolomite, interbedded with carbonaceous slates of the middle and upper krol, which transitionally grades upwards into the carbonaceous slate and subordinate limestone of Giwalikhet Member of Tal formation. Finally a succession of purple shales and siltstone interbedded with fine grain muddy sandstone, constituting the Narain Nagar Member of the Tal formation, overlies the Giwalikhet Member.

The sedimentary succession of the krolnappe is thrust, along the salari Thrust, over the spectacularly porphyritic Amritpur granite, which marginally grades into the quartz porphyry. The whole succession, then, is thrust over the thick sandstone of lower Siwalik along the MBT.

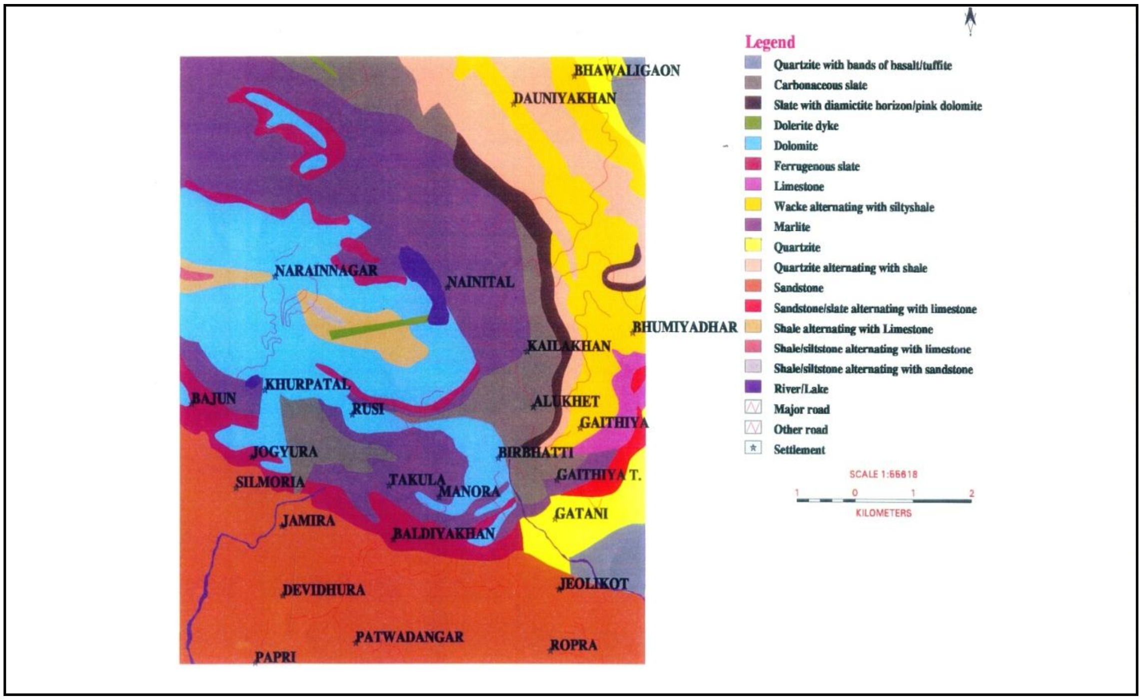

Figure 1: Lithological Map

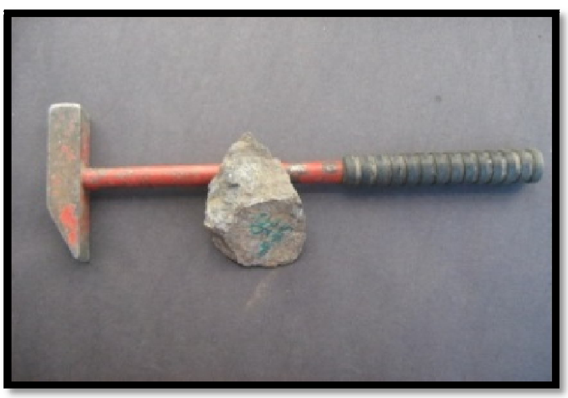

Plate: 1.0 *Plate:1.1*

Sample: Sandstone *Sample:Quartzite*

Area: Alukhet *Area: Ghorakhal*

GPS Coordinates: (N29˚ 22 ΄& 79˚ 28΄ E) GPS Cordinates:(N29 22 & 79 32E)

Elevation: 1795mElevation:1762 m


Plate: 1.2 Plate:1.3
Sample: Sandstone Sample: Shale
Area: Bajun Area: Nainital_Bhawali road
GPS Coordinates: (N 29˚21´ & 79˚ 24´ E) GPS Coordinates: (N29 23& 79 30E)
Elevation: 1584m Elevation:1692m


Plate: 1.4 Plate: 1.5
Sample: Limestone Sample: Sandstone
Area: Sat Tal Area: Sariya Tal
GPS Coordinates: (N 29˚ 22´ & 79˚ 32 ´E) GPS Coordinates: (N 29˚ 22´ & 79 ˚25´ E)
Elevation: 1483 m Elevation: 1595m


Plate 1.7: Rock outcrop with joints inShyamkhetPlate 2.8: Recumbent fold inBhujan

Figure 2: Some rock samples of the study area

6. Conclusion

After analysing and identifying the rocks of the study area it is clear that lithology is an important geological parameter which plays a dominant role in prognosis of landslide. It is appropriate to study this parameter for accurately delineating the hazard prone area. Lithology has control over the occurrence of landslide. It is seen that the softer rocks like phyllites and shales are more prone to landslide in comparison to the harder rocks like quartzites,granite etc. Most of the major slope failures have occurred commonly along the major thrust and faults. It is fruitfull to study this lithological structure which will ultimately help to take some mitigation measures against these hazardous mass slope failures in the study area.

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