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RELATION BETWEEN LITHOLOGY AND LANDFORMS: A CASE STUDY OF A PART OF RISHI KHOLA BASIN IN SIKKIM AND WEST BENGAL, INDIA

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Abstract

Lithology of a rock unit describes its physical characteristics visible at outcrop in hand or core sample or with low magnification microscopy, such as colour, texture, grain size or composition.On the other hand, landform in the earth sciences and geology subfields comprises a geomorphological unit and it is largely defined by its surface form. In the present study, lithological analysis on a part of Rishi Khola basin has been carried out using data collected from literature survey, field study, and also by computing it through GIS techniques.

There are three types of rock formations, such as Garubathan (297.42034 Sq.km), Rayeng(19.29 Sq.Km), Rangli Schist(29.18 Sq.Km).In Rishi Khola basin area, we observed huge variation of dip, strike, Slope and many folds, faults, joints. They influence the valley Shape, landforms and different geomorphic processes. These studies are helpful in understanding Hydrological, Geomorphological and Lithological characteristics of this basin area.

Keywords :*Lithology, Landforms, Dip, Slope, Rishi Khola Drainage basin.*

Short Profile

Rimi Biswas is a Student of M.Sc in Geography at West Bengal State University.

INTRODUCTION:

The present paper deals with The Impact of Lithology on land form in Rishi Khola basin area. Lithology the branch of geology that studies the mineral composition and structure of rocks macroscopically. The lithologic features include bay, peninsula, seas, and so forth, including sub aqueous terrain features such as submerged mountain ranges, volcanoes and the great ocean basins.

Therefore, Lithology plays a very important role in the shaping of landform. This is be- cause harder rocks are more resistant to erosion and protect softer rocks below from weathering and ero- sion. For example, if there is an area with many hard rocks, that area will most likely remain higher because the harder rocks can resist erosion. On the other hand, if there is an area with softer rocks, that area will most likely create plains or valleys.

Location of the study area:

The fieldwork of the present dissertation has been carried out at Rishi Khola basin area, which falls in the border area of West Bengal and Sikkim. Our work has been done in a small part of Rishi Khola basin. The area lies between $27^0$9'4. 40'' N to 27^0 10' 55.37'' N and 88^0 37' 16.20'' E to 88^0 38' 42.97'' E (top sheet no.73A /12).

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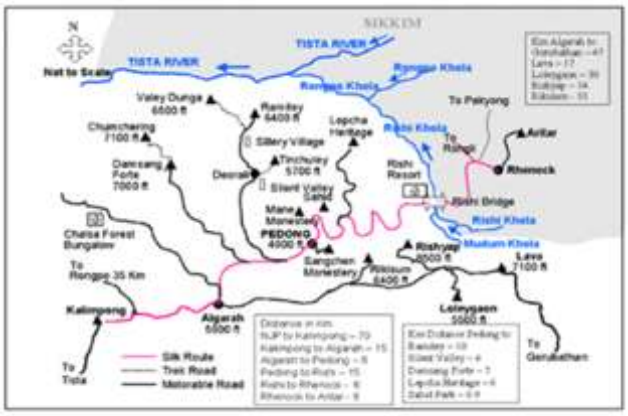

Fig. 1: Location of Rishi Khola Basin

Methodology: This research work has been prepared following a systematic methodology, which has been conveniently subdivided into the following stages:

Literature Survey: At this stage, we had gone through an extensive literature survey to find out the trend and observation of previous work.

Collection of secondary materials: The secondary data and maps were collected from various sources at this stage

Collection of primary data: Observation and investigation of study area, collection of data, necessary photos, and samples of rocks etc have been collected from the field survey. Different instruments like Clinometer, Abneys level, accessories like tape, hammer, acid etc were used.

Analysis of data: The collected data were analyzed with the help of following techniques:

- Techniques: The basic techniques adopted in this paper are as follows: Bar diagram, Mapping, Regression line, and Scatter diagram.
- Tools: The software used is M.S Excel 2007, M.S Word 2007, Adobe Photoshop 7, TNT MIPS 2010, and Paint.

Lithological Analysis of the Basin and Surroundings:

On the basis of our geological map, the entire area of the Rishi Khola and surroundings comprises of468.9474 sq.km. The latitudinal & longitudinal extension of this area is 27^0 5'N to27^0 15'N & $88^0$30' E to 88^0 45'E.

This is predominated with Garubathan formation (297.42034 sq.km). Besides, this area consists of Darjeeling Gneiss (31.99532 sq.km), Kanchenjunga Gneiss (30.07874 sq.km),Lingtse Gneiss (10.5235 sq.km) and Rangli Schist (29.18286 sq.km). This areal distribution (Table no.3) is shown by a Bar Graph (Fig.2). Within these we found three types of formation in our study area lies between 27^0 9' 4.40'' N and to 27^0 10'55.37" N and 88^0 37' 16.20" E to 88^0 38' 41.97" E.

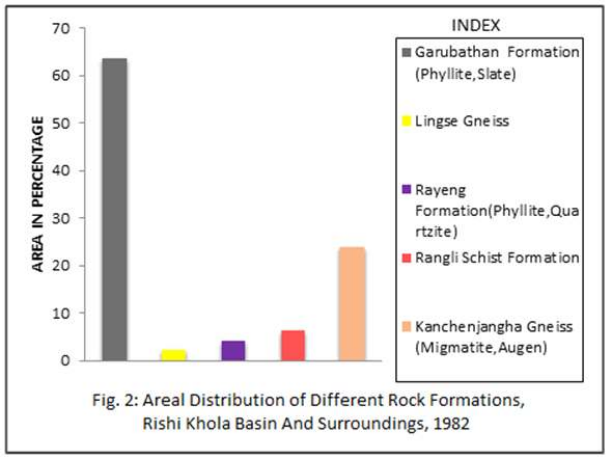

Fig. 2: Areal Distribution of Different Rock Formations, Rishi Khola Basin And Surroundings, 1982

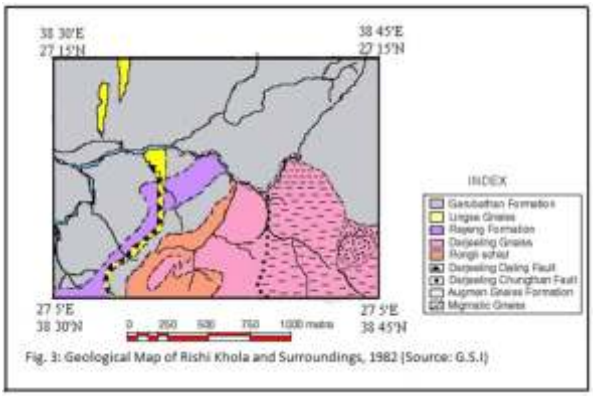

Fig. 3: Geological Map of Rishi Khola and Surroundings, 1982 (Source: G.S.I)

Daling Group

The name 'Daling' was coined by F.R.Mullet (1875). This group of rocks gets mostly formed in the region of Kalimpong hills.Strati graphically, the Daling group is oldest group of the metasedimentary rocks deposited over basement complex. But due to the thrusting these rocks have made way to the upper most position of tectonic succession in these area. Therefore, it has been very difficult to decide the exact stratigraphic position of these rocks.

In our study area, we found the Daling group of rocks in both side of Rishikhola Valley.

Along the left bank we found Rayeng formation and on the right bank Garubathan formation.

Rangli Schist

These rocks are exposed over a small area. There are hard, massive, and highly jointed dark gray schist. Apparently, from showing the characteristics schistosity these rocks exhibit prominent drag and roll effects, particularly when in contact with more competent quartzite. The quartzite's of this region occur as prominent ridges e.g. Gok ridge.

In our study area, we found these types of rock at the left bank of MandamKhola, a left bank tributary of Rishi Khola.

RESULTS AND DISCUSSIONS:

Geological Cross-Section Analysis:

Geology is intimately related to geography as both of them belong to earth sciences and have a common field in geomorphology. The surface configuration is largely influenced by the underlying structure and lithological characteristics. The pattern of rock exposure, as shown in geological maps, is a resultant effect of the interaction between the operating geomorphological process and the rock beds present.

Relief:

The profile along the section line, AB (Fig.4) shows a variable relief which is low(about 600 m) in the valley along the north eastern part and more or less flat in the north eastern part and higher in the south eastern part (>890 m).

Sequence of Beds:

As revealed in the geological section along AB, we observed series of rock bed of Precambrian series. The sequence of beds may be tabulated in the following manner:

Table: 2- Sequence of Beds

Name of the Rock Beds	Signs	Group
Rangli Schist		Darjeeling
Rayeng formation		Daling
Garubathan formation		Daling

STRUCTURE:

From this geological section, we observed that it is a uniclinal structure. The rock beds dip at the angle of 32 degree towards southeast. In the southwest we observed a big exposure of Rangli Schist, which belongs in Darjeeling group the length of the exposure, is near about 100 m (Table no.4). The beds of both group however have formed a homoclinal structure.

CORRELATION BETWEEN STRUCTURE AND RELIEF:

As revealed from the geological section, the relief forms an undulating topography with ridge and valley. The scarp slopes and dips are well distinguished and they vary in steepness. The highest elevation, which is about 950 m is observed in an upland towards south west, which is mostly occupied by Rayeng formation. The lowest elevation is less than 650 m in the river valley.

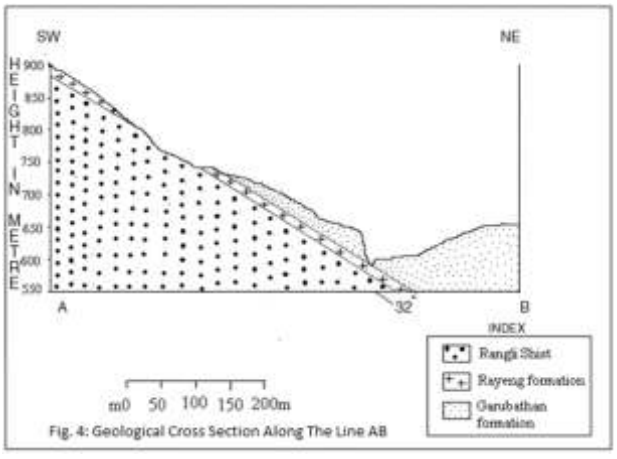

Fig. 4: Geological Cross Section Along The Line AB

The slopes of the rock bed have followed the direction of the dip. Thickness of the Rayeng formation is very low (15 m) it is less hard than Rangli Schist. So towards southeast the softer

rock has been eroded and has exposed the underlying Rangli Schist.

Characteristics of Rock Specimens Collected from Field:

As such the part of the Rishi Khola basin surveyed by us belongs to the exposures of the Daling group in general, but after the examination of rock beds in the field it appeared that the Rishi river in this part of its course has followed a lithological contact between the Rayeng formation and the Garubathan formation of the Daling's. On the left bank, the exposures of valley walls are composed of phyllite and quartzite, whereas on the right bank the exposures belong to phyllite and slates. These phyllites on the right bank are again slightly schistose in character at places.

Plate no. 1: Phyllite Schist, Rishi Khola Basin

The rock specimens collected from the field can be described in the following manner as far as the mega-scopic examination is concerned.

The specimen (Plate no.1) on the right bank is gray phyllite schist with very shiny and smooth appearance. The rock dissociated itself along the foliation planes. Schistosity is not very prominent, though the true lamination is absent. However, the micaseous minerals composing they are micro grained and cannot be separated from the main mass.

On the left bank, the exposures of the Rayeng formation are observed. The rock beds mainly belong to phyllite, though the beds of quartzites are well observed. The phyllites are slightly foliated at places. On the other hand, the quartzites are well jointed and exhibit the evidence of sheet weathering. However, these exposures are not very extensive and occur impersistently. The quartzites being more resistant open allowed the rock walls of phyllite to recede towards the hill slide. This has resulted in grooves and elongated pits along the rock wall.

These rocks are again having a great no. of quartz and feldspar veins where assume a schistose character.

The specimen (Plate no.2) shows the quartz are off white or light gray in colour, when the phyllites are silver gray in appearance.The contact between the phyllite and quartzite has made the surface of the quartzite slightly shiny, though towards the inner part of the rock there hardly any luster.

Plate no. 2: Specimen of Rayeng Formation, Rishi Khola Basin

The specimen (Plate no.3) shows the biotite schist which may belong to the Rangli schist formation. Besides foliation the rock has spots of garnets. However, at places, the rock shows slightly banded nature with alternate granulose and schistose layers but these bands are discontinuous.

Plate no. 3: Rangli Schist, Rishi Khola Basin

Observed Dip, Strikes and Slope on the Rocks:

Dip and strike are related to each other. They are two important parts of a rock bed, a fold, a fault and foliation. In Rishi Khola basin area, we observed huge variation of dip and strike (Table no.5). At the right bank of the river on the Garubathan formation the foliation dip varies from 160 to 40 towards southeast (Fig.5). Within them the highest dip is found at relatively upstream section of the river (27^0 10'33"N and 88^0 37'48.4"E) where the rocked dips 430 directed towards southeast. On the other hand the lowest dip, 16 degree we found near the confluence of Rishi Khola and MandamKhola (27^0 10'11.78"N and 88^0 38'15.48''E) which is directed towards south east.

At the left bank of the river in the Rayeng formation, we also found a huge variation of dip. There the dip varies from 510 to 80. Within them the highest dip, 510 we found at 27^0 10'20.72"N and 88^0 38'1.61"E which is directed towards southeast. The lowest dip(8 0) is found on the same formation with same direction at 27^0 10' 13.47"N and 880 38' 6.8"E. Almost all foliation dips of this formation is directed towards south east but only two dips are directed towards east north east (36 0) and south west (480). Towards the upstream at the left bank of MandamKhola we found three rock exposures of phyllite. The foliation dip of these exposures vary from 10 ^{0}to 32 ^{0} towards south east.

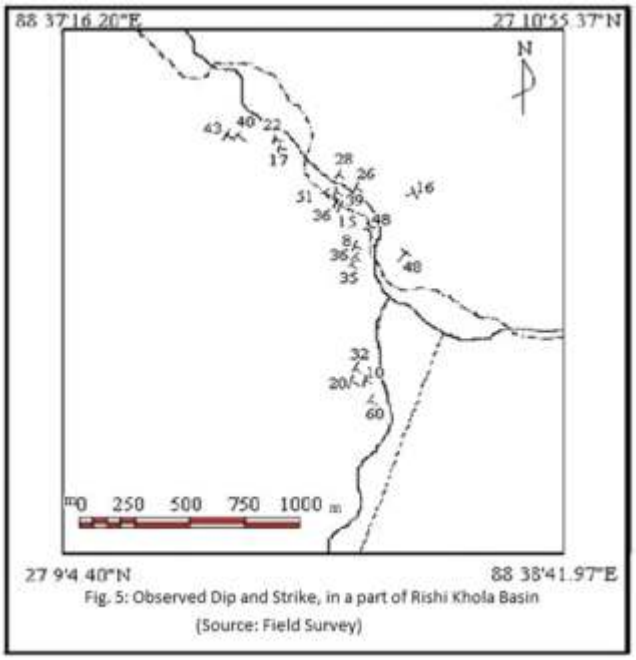

Fig. 5: Observed Dip and Strike, in a part of Rishi Khola Basin
(Source: Field Survey)

Again towards the upstream at the left bank of MandamKhola we found the bedding joint of the Rangli Schist and the Rayeng formation. At 27^0 9'37.58" N and 88^0 38' 6.89" E the dip of the Rangli Schist is 60 0 towards south-south-east. Slopes of this area are generally towards the river, i.e. the Rishi Khola. That means the slope of the Garubathan formation is towards the southwest and the slope of Rayeng and Rangli Schist formation is towards the northeast.

In Garubathan and Rayengformation, we found a variety of slopes. The slopes of Garubathan formation vary from 19^0 to 78^0 and the average slope is 37^0 33'. On the other hand, in the Rayeng formation, the slopes vary from 10^0 to $41^0$and the average slope is $27^0$13'45".

The slope of the Rangli schist is about 51^0 20' towards the MandamKhola. But the slope of the Daling group of rocks Garubathan and Rayeng formation towards the Rangporiver, towards north.

Correlation between Dip of Rocks and Surface Slope:

The relationship between rocks' dip and slope is shown with the help of scatter diagram and linear trend line (Fig.6). It is proved from the

scatter diagram that whenever the dip of the rock increases the slope at that time also increases. For example, in that time where the dip is 60^0 the slope at that point is 51.30 (Table no.6). Again, when the dip is 30.15^0 the slope at that point is 21.30. Thus, it can be proved that there is a positive correlation between the dip and vulnerability. That the relationship is very strongly positive can be proved by the value of 'r' is 0.875.

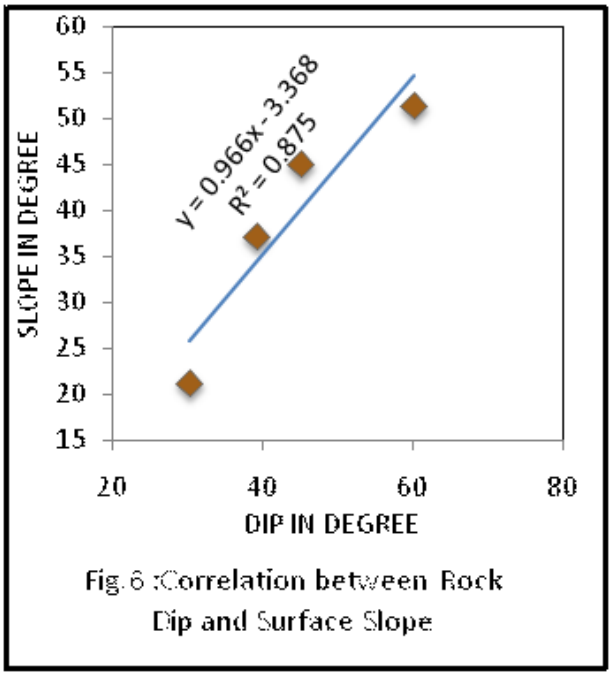

Fig.6 :Correlation between Rock Dip and Surface Slope

With the increase in dip, slope increases considerably and consequently it puts an impact on the micro geomorphological environment. The positive relation between dip and slope proves that the slope of the rock beds follows the dip of the underlying rock beds.

Correlation between Dip of Rocks and Vulnerability:

The relationship between dip of rock beds and vulnerability is shown with the help of scatter diagram and linear trend line (Fig.7). It is proved from the scatter diagram that whenever the dip of the rock increases the vulnerability of the rock this time increases also. For example, in that time where the dip is 30.15^0 the vulnerability at that point is only 5 (Table no.7). On the other hand when the dip is the highest that 60^0 the vulnerability increases to 15. Thus, it can be proved that there is a positive relation between dip and vulnerability and the relationship is very strongly positive can be proved by the value of 'r' is 0.906.

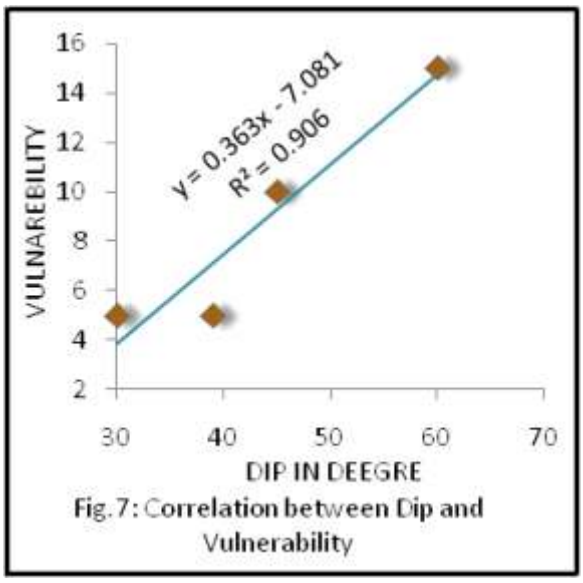

Fig.7: Correlation between Dip and Vulnerability

With the increase in dip, slope increases considerably and consequently it exerts an impact on micro geomorphological environment. As the slope increases geomorphic hazards also may get intensified depending upon the other factors. Because in a hilly area slope and the physiographic is one of the most important control upon the physic cultural environment. Geomorphic hazards like landslide are intensified by slope steepness thus, influencing the vulnerability of the area. Again high dip and slope also make the cultural creation like building, roads and other establishment vulnerable.

slope of a hilly area are towards the same direction or valley, side then the risk of vulnerability increases. Hence allthe man-made creation like building, road, and other establishment in valley side becomes vulnerable.

Correlation between Rock Strength and Slope:

The relationship between rock strength

and slope is shown with the help of scatter diagram and linear trend line (Fig.10).From this scatter diagram, it is proved that whenever the strength of the rock is high the slope of the rock is also high. For example in those points where the rock strength is 3 the slope in those points are 37.25 degree and 450 respectively (Table no.6, 8). Again, when the rock strength is least (i.e. 1), slope decreases to 21.3^0.Thus, it can be proved that there is a positive relation between the rock strength and slope. That the relationship is moderately positive can be proved by the value of 'r' is 0.357.

Generally when the Strength of the rock increases, the slope increases considerably. Because the erodibility of harder rock is lesser than the softer rock. The rate of weathering is also low over harder rock than the softer rock. So the harder rocks help in the development of steep slope.

Relationship among the Rock Strength, Surface Slope and Weathering:

The relationship between rock strength and weathering is shown with the help of Rader diagram (Fig.12). The diagram is the proof that if the rock strength increases the slope increases but the rate of weathering decreases. For example in this point that the rock strength is low, 1, the slope is also low, 2 but the rate of weathering is moderately high, 5. On the other hand when the rock strength is high i.e. 3, the slope is also high (4) but the rate of weathering decreases to 9 which indicate the rock is slightly weathered (table no.6, 8, 9.). Therefore, we can say there is positive relation between rock strength and slope. But there is a negative relation between rock strength and weathering.

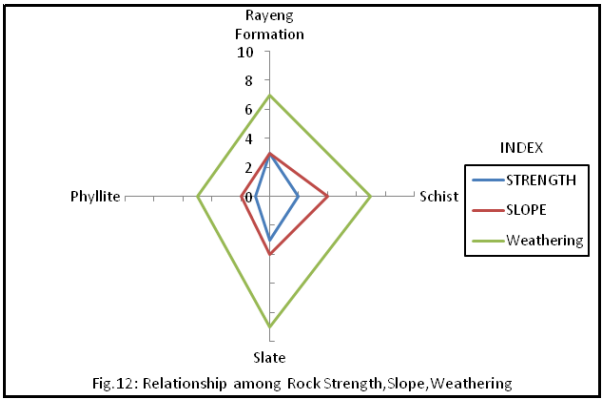

Fig.12: Relationship among Rock Strength, Slope, Weathering

Correlation between Rock Strength and Altitude:

The relationship between rock strength and altitude is shown with the help of scatter diagram and linear trend line (Fig.13). This diagram is proved that with the increase strength of the rock the altitude increases considerably (Table no.3, 8). This diagram represent there is a positive relation between the rock strength and altitude. That the relationship is slightly positive can be proved by the value of 'r' is 0.107.

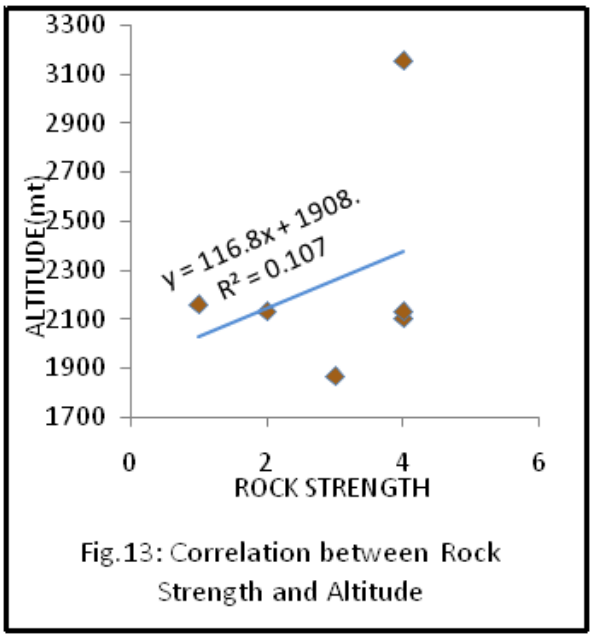

Fig.13: Correlation between Rock Strength and Altitude

In general, with the increases of rock strength, altitude also increases. But in this diagram we found some exceptions. Sometimes the strength is medium but the altitude is lower

than the softer rock formation. For example, the altitude of Garubathan formation (softer rock) is 2161 m where the altitude of Rayeng formation (harder rock) is 1871.472 m. Therefore, we can say not only the Lithology but also geology (heterogeneous character) and other factors are influence the topographic variation of this region.

Correlation between Rock Strength and Relative Relief:

The Fig. 14 is shown that the relationship between rock strength and relative relief with the help of scatter diagram and trend line. From this diagram we can say that there is a very negligible negative relation between rock strength and relative relief (Table no.3, 7). Most of the cases the relative relief does not depend upon the rock strength. The value of the 'r' is -0.083 that proves that the relation is slightly negative.

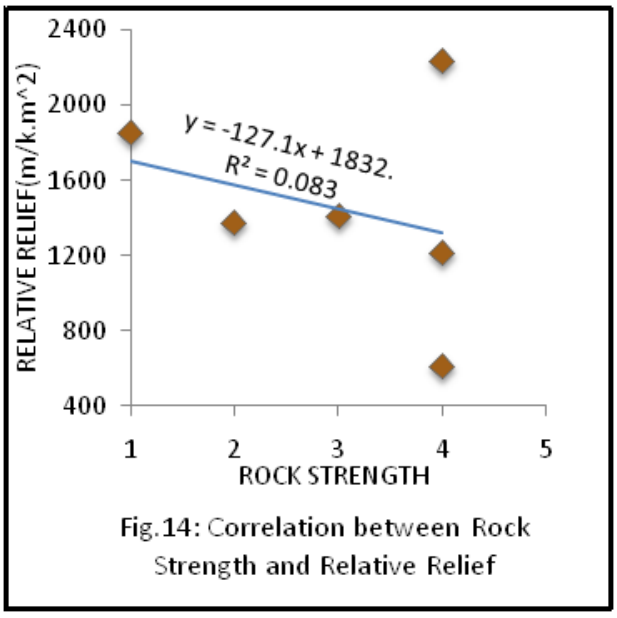

Fig.14: Correlation between Rock Strength and Relative Relief

So it can be proved that the relative relief of this area is totally (99%) influenced by the geologic and other factors.

Conclusion: Form our study, in the Rishi Khola Basin it can be understood that lithological characteristics are of great importance in the development of landform in this area. The strike and dip of the rocks positively affects the slope character here also affecting the vulnerability of the slopes as the rock strength directly affects their vulnerability to weathering.

However, lithology is not the most important controlling factor of landform here. The natural forces which affect the processes have greater control on the development and modification of landform. Inspite of this the importance of lithology lies in the materials forming the region.

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