Investigation of Flexural bulge of the Indian Plate for Controls on Landscape Evolution

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Abstract

The morphology of a river channel is driven by multiple forcing factors that can be either external or internal. The internal factors, such as the variation in rock strength, lineament orientation, and fracture density can be an impelling force in the landscape evolution of a slow uplifting terrain. The spatial variation in the internal factors may result in heterogeneity in fluvial erosion rates, which may produce false signals of active tectonics in a terrain. The Himalayan orogeny has resulted in an upward flexure in the Indian crust known as a peripheral forebulge. The uplifted Vindhayan plateau is proposed as the depiction of this flexure. The bending of the Indian plate has resulted in the generation of tensile forces in this area. These forces have resulted in the formation of large-scale lineaments, which are roughly aligned parallel to the axial plane of the forebulge. This study highlights the role of lineaments, rock strength, and fluvial erodibility in the tectonics of forebulge. We used N-type Schmidt hammer to measure the intact rock strength of lithologies met in the Vindhayan plateau. We calculated the Normalized steepness index (Ksn) to assess the fluvial erodibility of the channels. We calculated swath profiles and local relief distribution to understand topographic variation. Further, we looked at the knickpoint distribution and tried to correlate it with major lineaments and lithological boundaries. Finally, we tried to understand the relationship between the lineament distribution and regional tectonics of the forebulge. We find that there is a significant difference in fluvial erodibility between the weakest and strongest lithologies. We observed that the lineaments act as the conduits for rapid erosion and knickpoint formation. The Ksn values are relatively high where we encountered the hard lithologies, resulting in the formation of vertical knickpoints (waterfalls). We have observed a correlation between, Rock strength variation, topographic relief, knickpoints, and Normalized steepness index. Our results suggest that spatial variation in rock strength and lineament pattern is playing a crucial role in the landscape evolution of the Vindhayan plateau. We finally propose a model to relate lineament orientations and lithological variations with slow uplift of the forebulge.

INVESTIGATION OF PERIPHERAL FOREBULGE OF THE HIMALAYA FOR CONTROLS ON LANDSCAPE EVOLUTION

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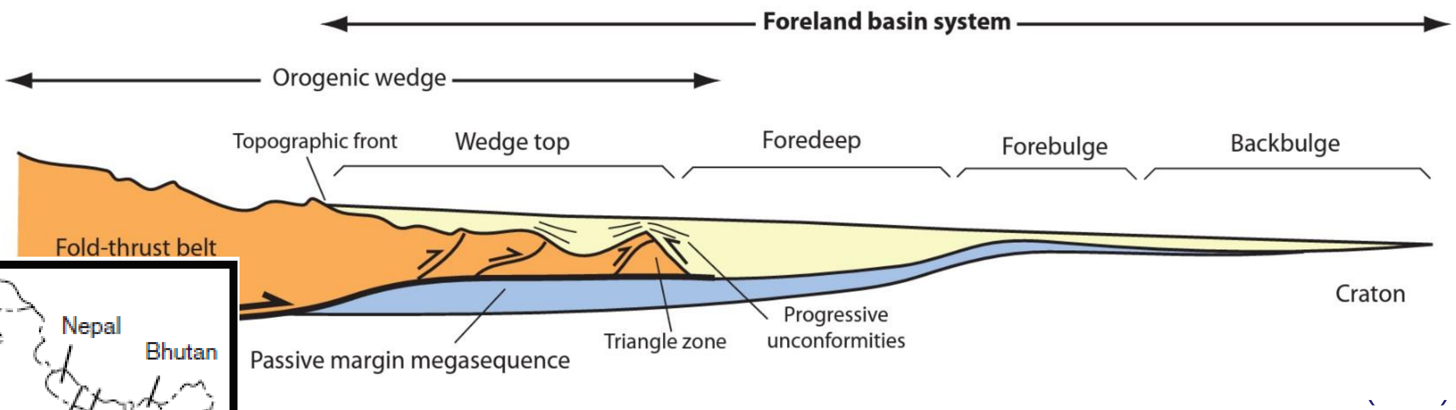
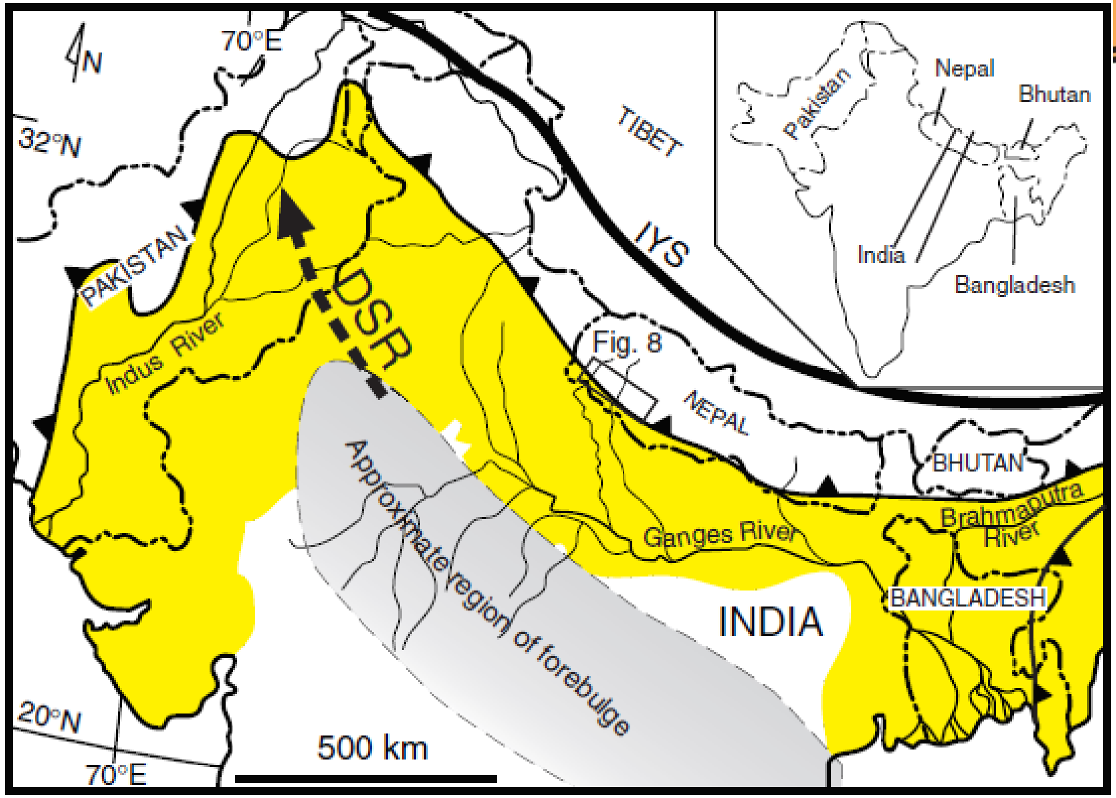
AGU FALL MEETING

HIMALAYAS-THE FORMATION OF FOREBULGE AND UPLIFTED CENTRAL INDIAN VINDHYAN PLATEAU





Taken from DeCelles(2012)

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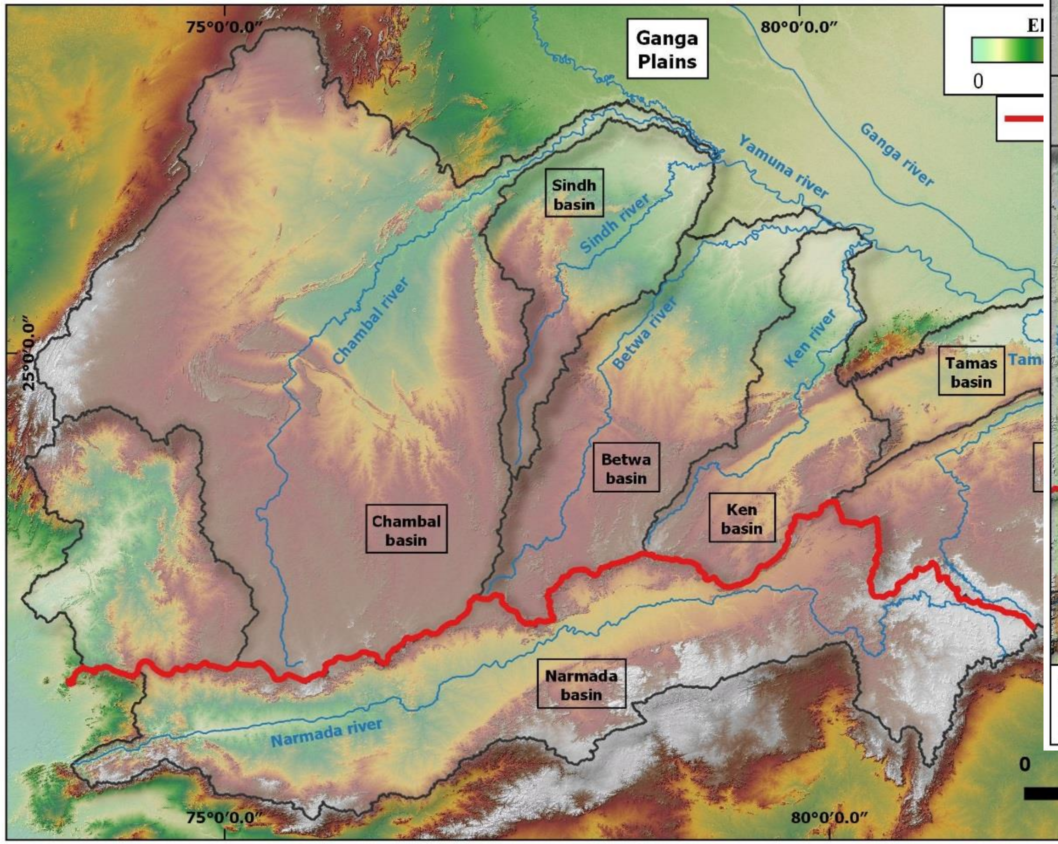
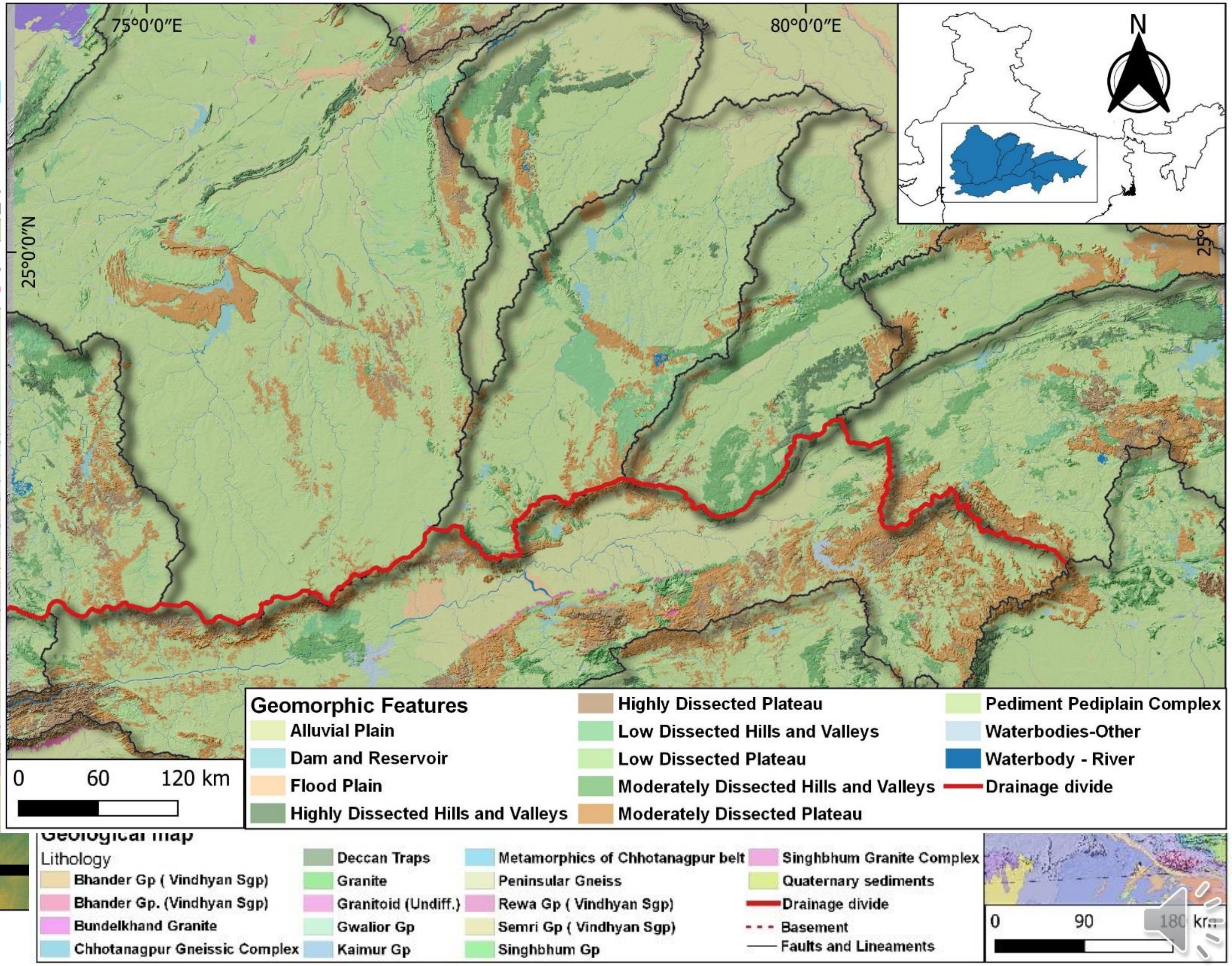
STUDY AREA: CENTRAL INDIAN VINDHAYAN PLA





METHODS: 1. <u>TOPOGRAPHIC ANALYSIS</u>: WE CALCULATED NORMALIZED STEEPNESS INDEX (KSN) FOR THE RIVERS FLOWING ON THIS LANDSCAPE, USING THETA (Θ) = 0.45 & A0 = 1M^2.

- WE USED CHI COORDINATE BASED APPROACH TO CALCULATE KSN, USING SRTM DEM 30M.
- KSN CAN BE USED AS A PROXY TO RELATE THE FLUVIAL ERODIBILITY OF CHANNELS.
- WE USED LSDTOPOTOOLS TO CALCULATE THE KSN AND CHI VALUES

$$S = k_s A^{-\theta}$$

LSD Topo Tools

METHODS: 2. <u>FIELD ANALYSIS</u>: WE MEASURED INTACT ROCK STRENGTH OF MAJOR ROCK TYPE EVIDENT IN FOREBULGE/ PLATEAU REGION USING A N-TYPE SCHMIDT HAMMER.

- THE ROCK STRENGTH IS INVERSELY PROPORTIONAL ERODIBILITY, I.E HIGHER THE ROCK STRENGTH LOWER WILL BE THE FLUVIAL ERODBILITY

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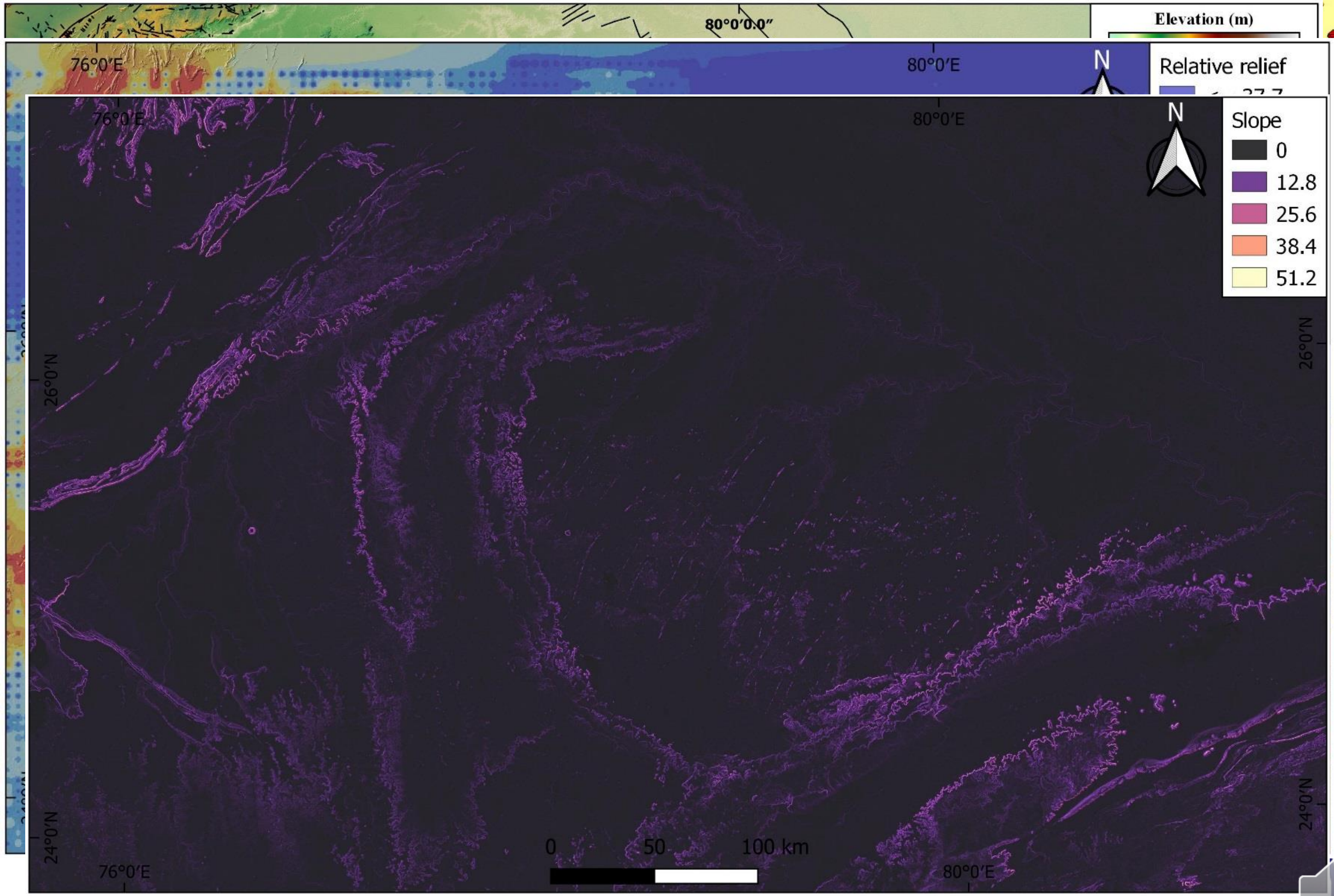
METHODS: 3. GIS ANALYSIS: WE USED LINEAMENT DATA OF CENTRAL INDIA PROVIDED BY GSI TO CONDUCT LINEAMENT ORIENTATION ANALYSIS.

- WE CALCULATED SLOPE AND RELATIVE RELIEF TO IDENTIFY THE ZONES HIGHER SLOPES AND RELIEF VARIATION.
- WE ALSO GENERATED TOPOGRAPHIC SWATH PROFILES TO BETTER UNDERSTAND TOPOGRAPHIC VARIATION IN THIS REGION



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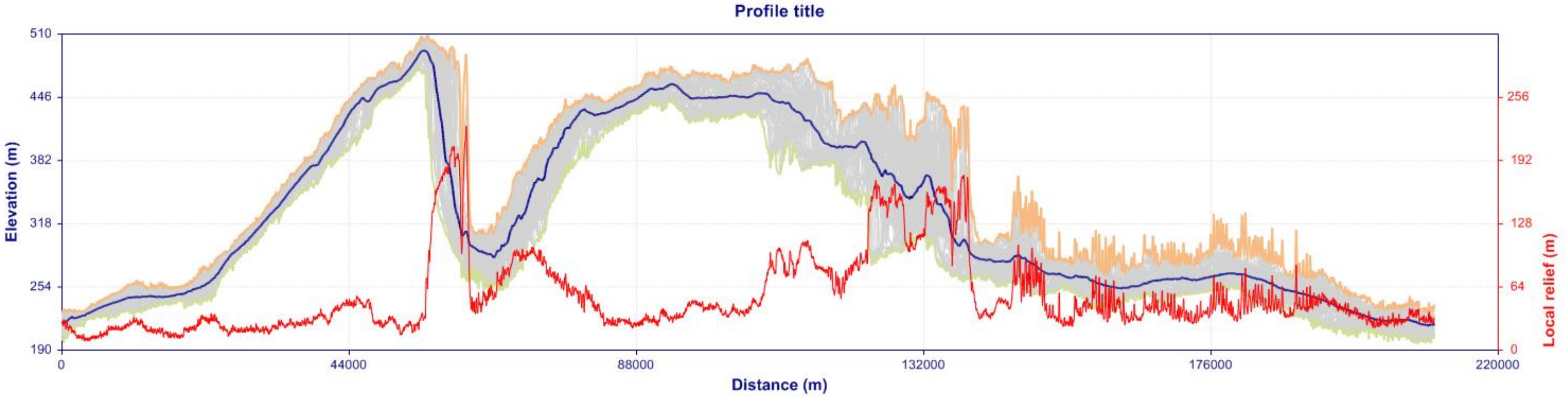

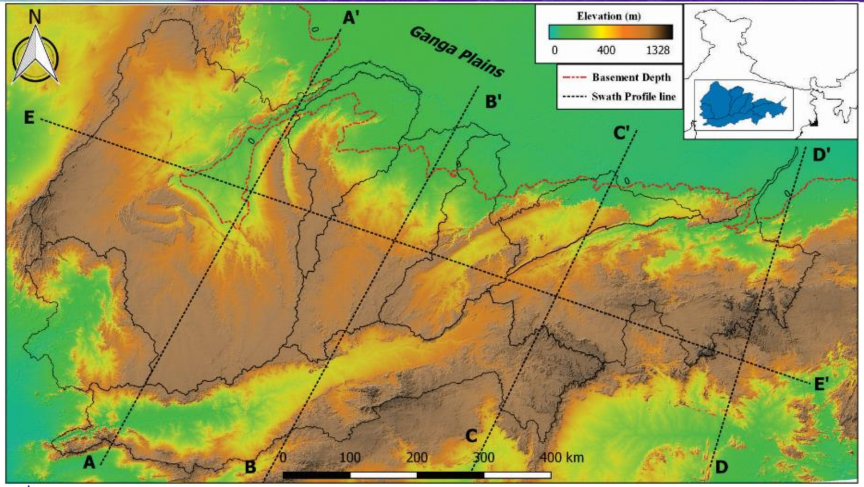

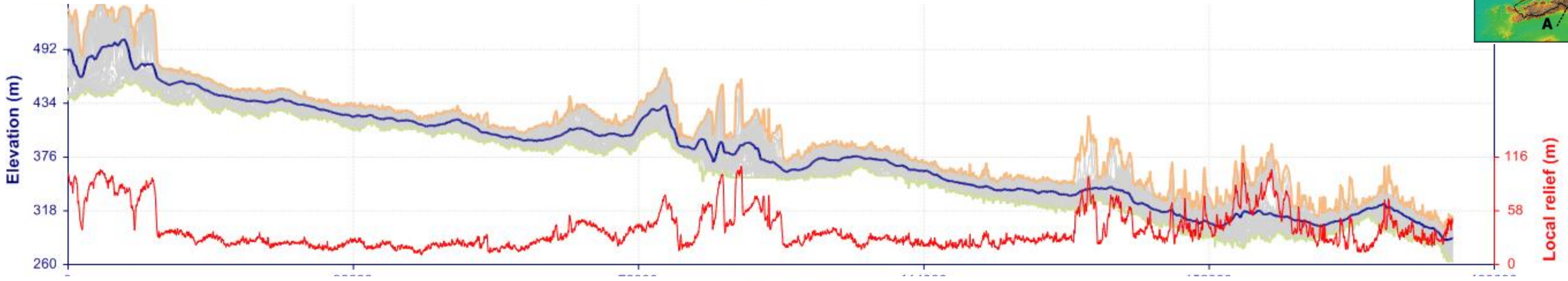

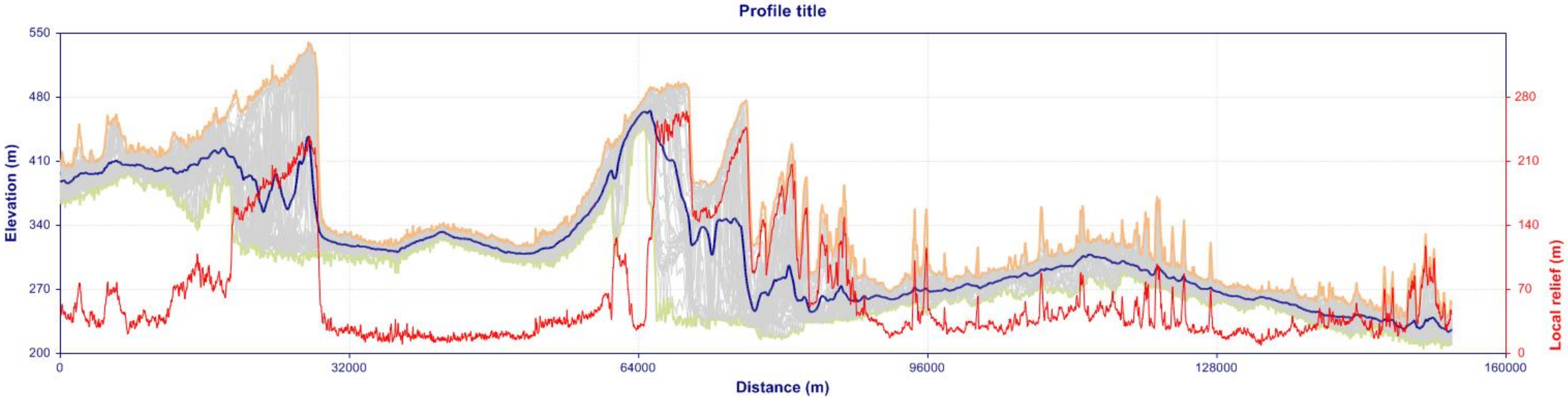

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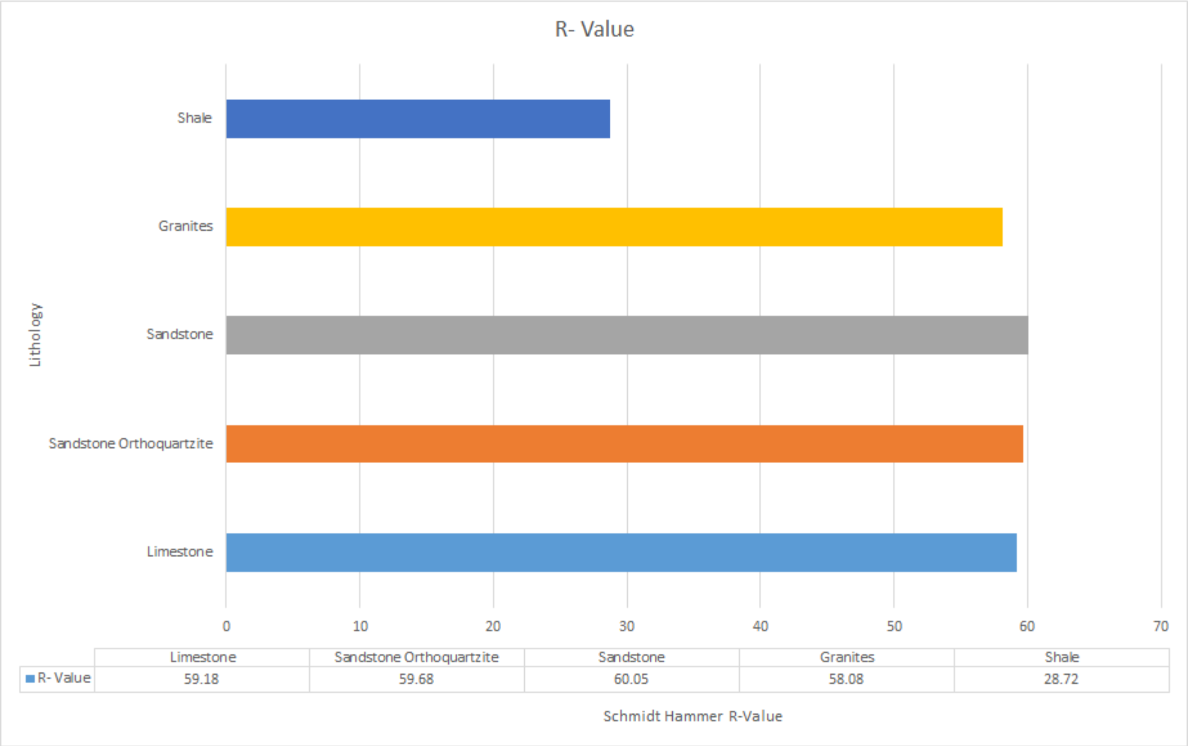
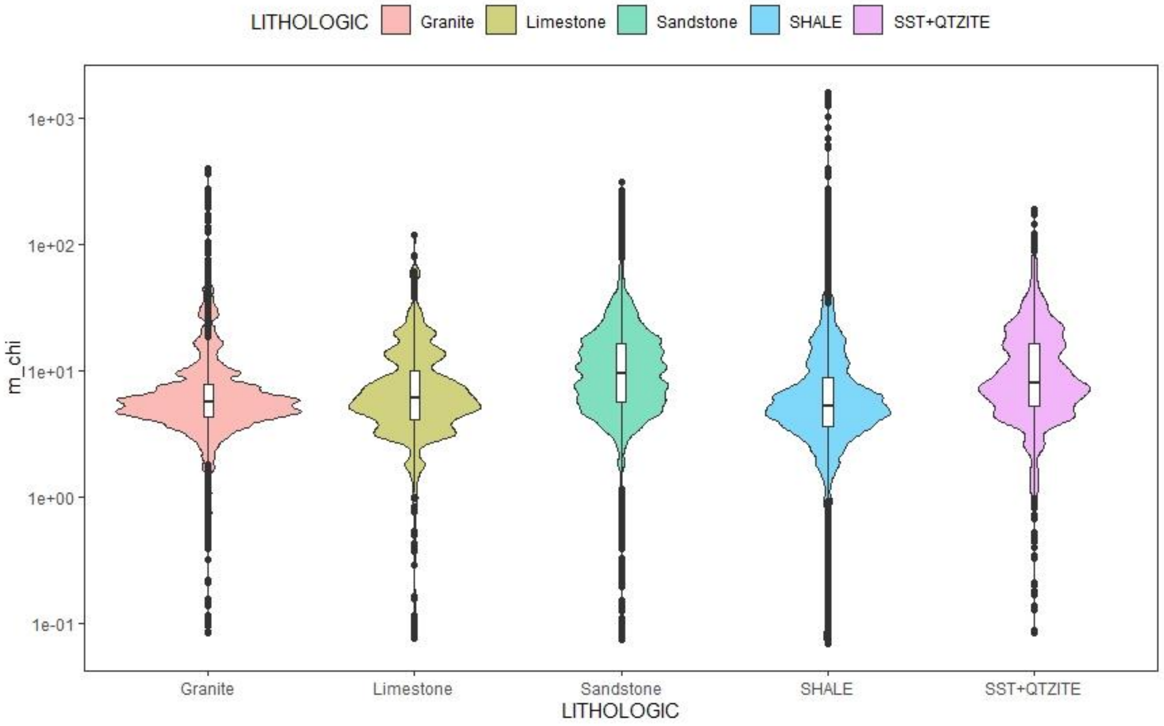
RESULT: ROCK STRENGTH DATA AND NORMALIZED STEEPNESS INDEX (KSN) DATA SUGGEST THAT LITHOLOGY PLAYS A MAJOR ROLE IN GUIDING EROSIONAL PATTERN ON CENTRAL INDIAN FOREBULGE REGION



	Limestone	Sandstone Orthoquartzite	Sandstone	Granites	Shale
R- Value	59.18	59.68	60.05	58.08	28.72



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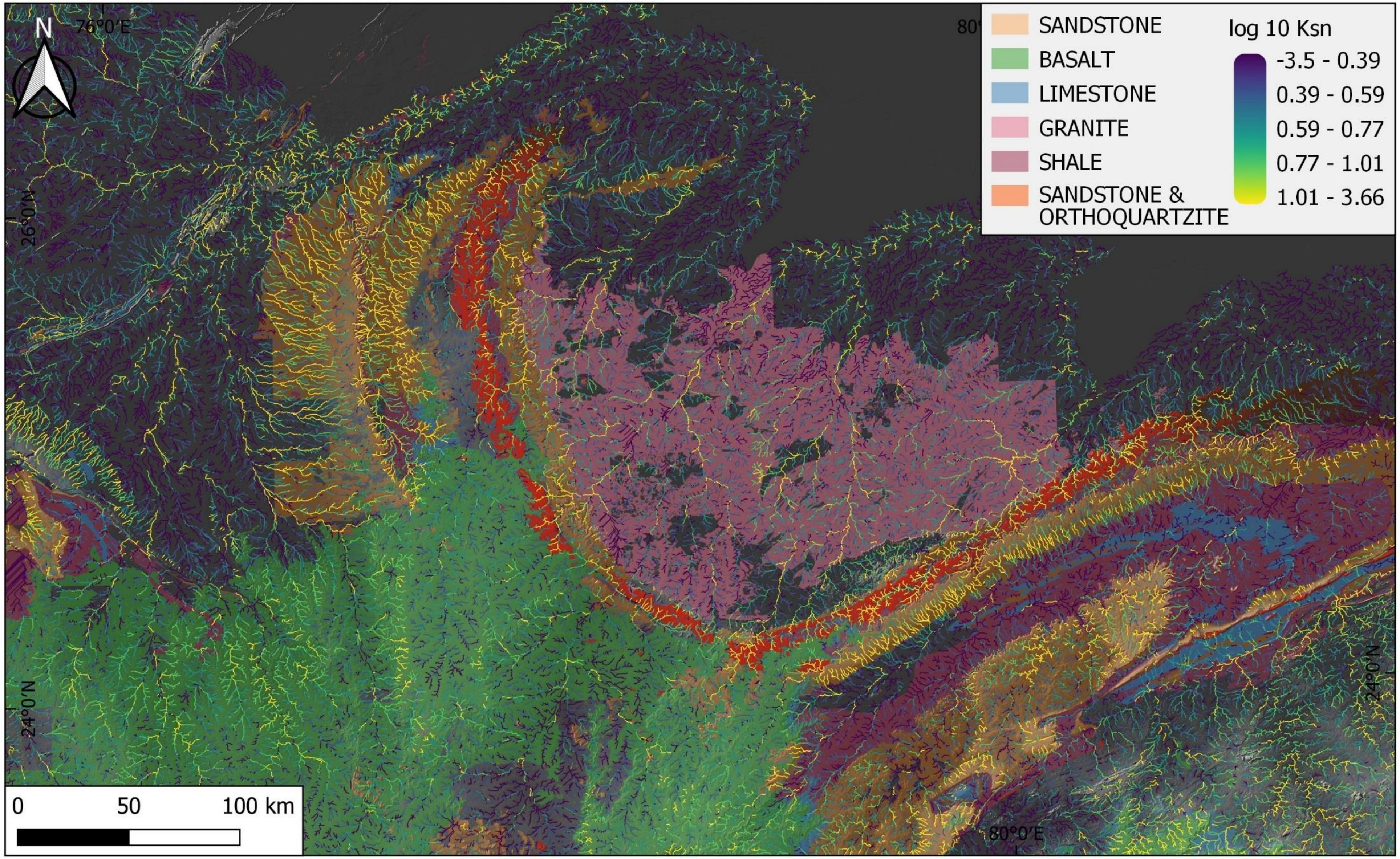
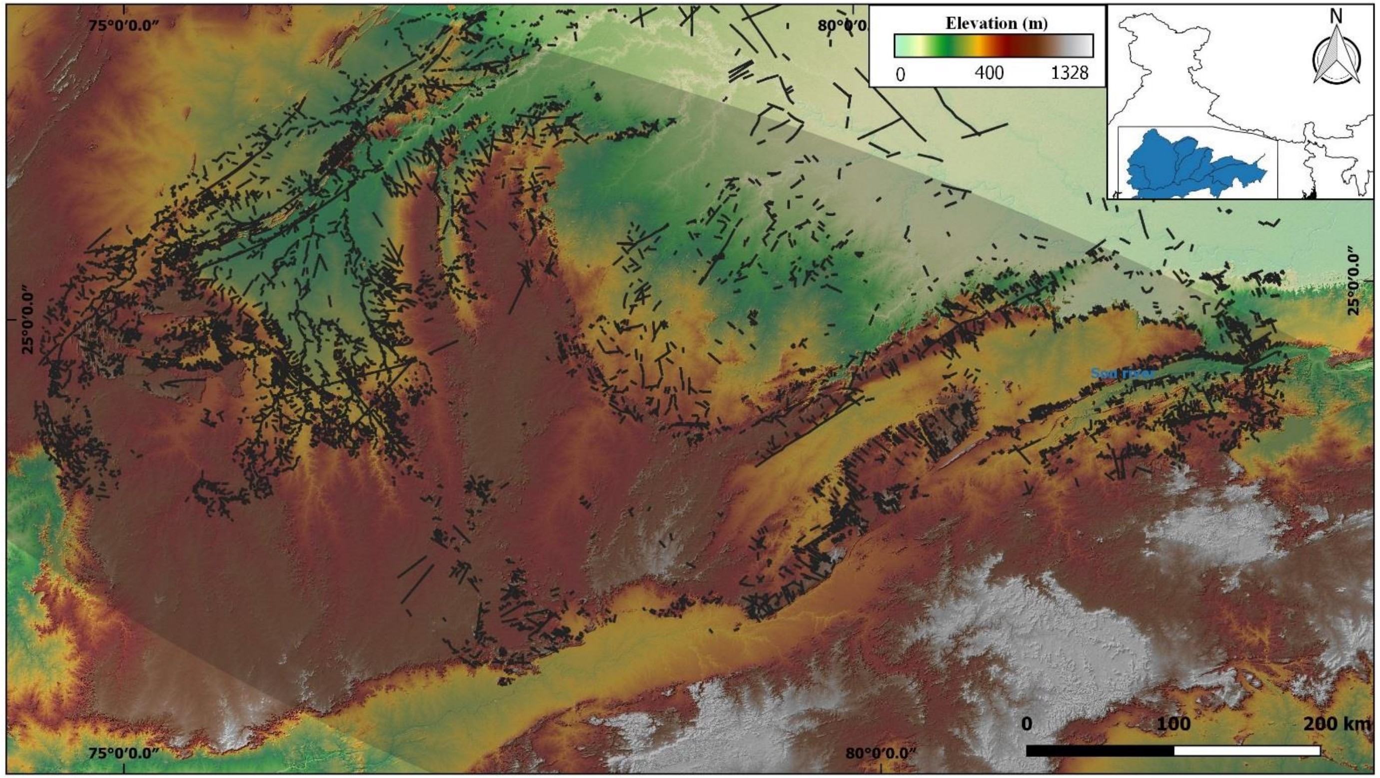
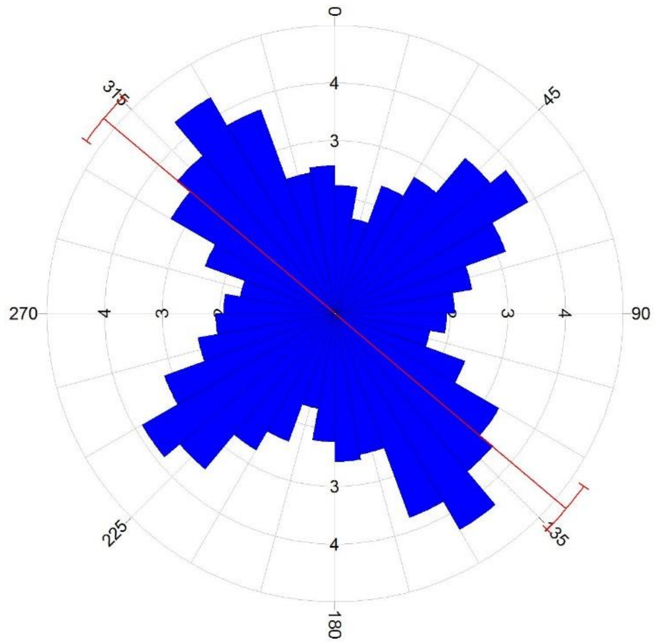

N
76°0'E
80°
26°0'N
24°0'N
24°0'N
80°0'E
SANDSTONE
BASALT
LIMESTONE
GRANITE
SHALE
SANDSTONE & ORTHOQUARTZITE
log 10 Ksn
-3.5 - 0.39
0.39 - 0.59
0.59 - 0.77
0.77 - 1.01
1.01 - 3.66
0
50
100 km

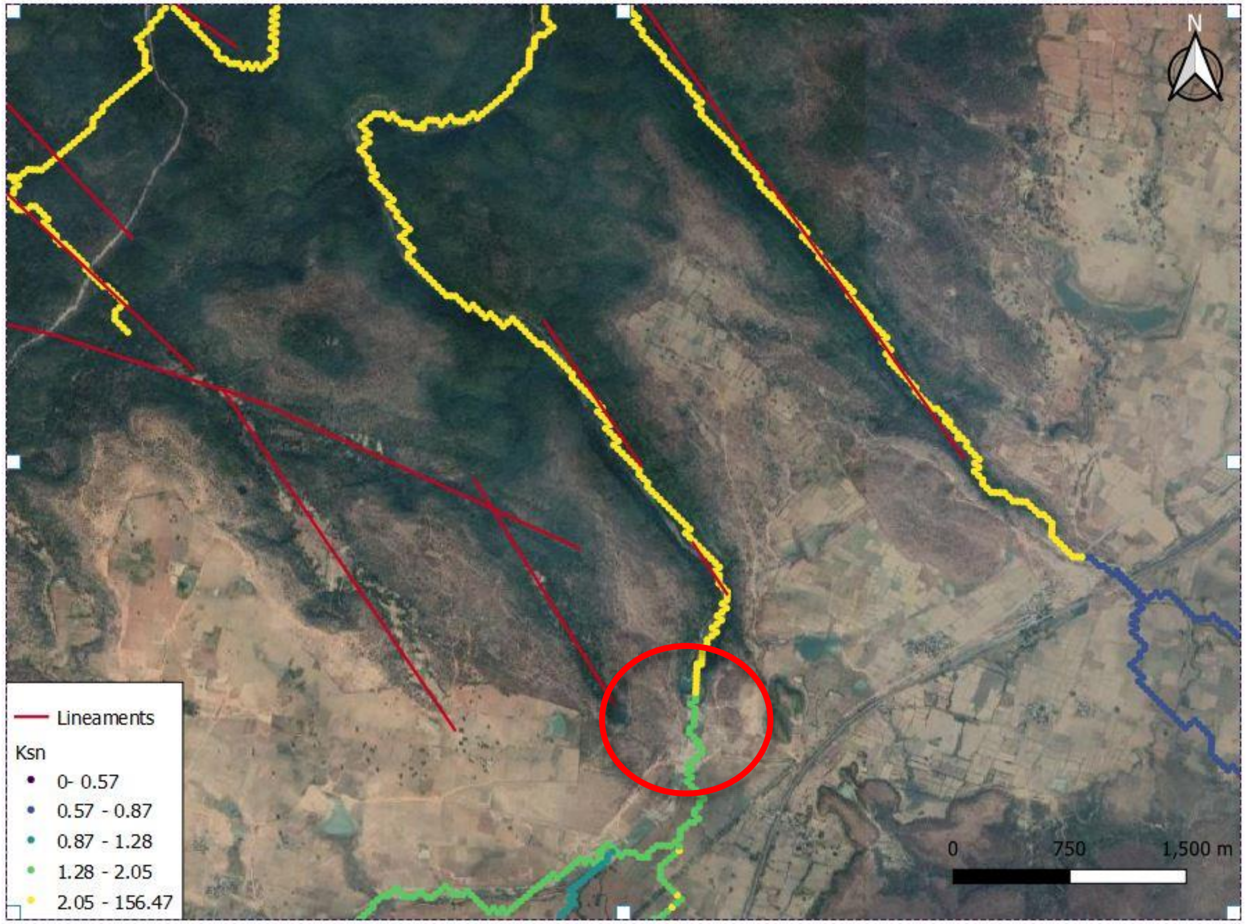
RESULT: LINEAMENT ORIENTATION ANALYSIS HIGHLIGHTS THAT MAJOR LINEAMENTS ARE ALIGNED ALONG NW-SE, WHICH IS APPROXIMATELY PARALLEL TO HIMALAYAN MOUNTAIN BELT. THE KNICKPOINTS ARE ALIGNED ALONG THESE LINEAMENTS.



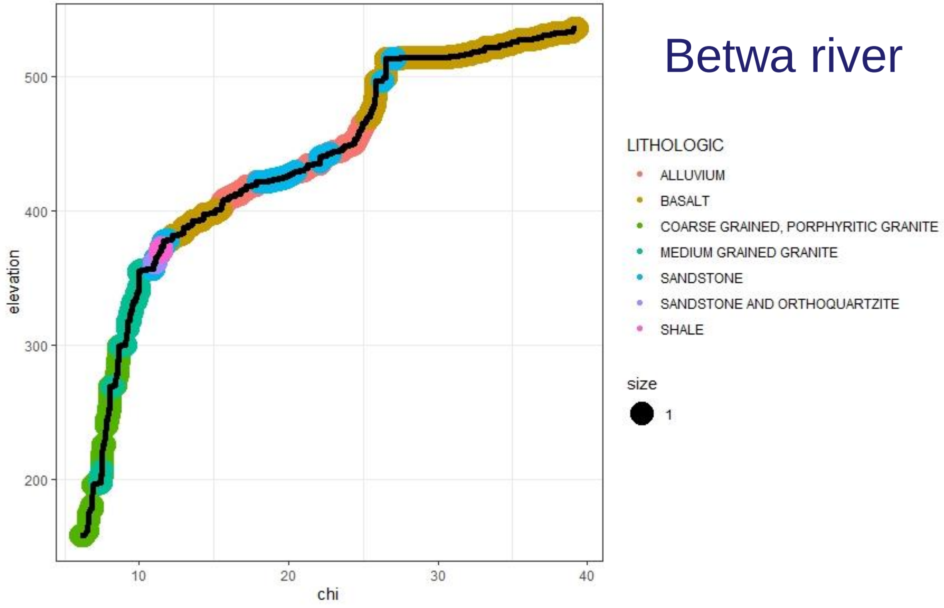


Rose Diagram

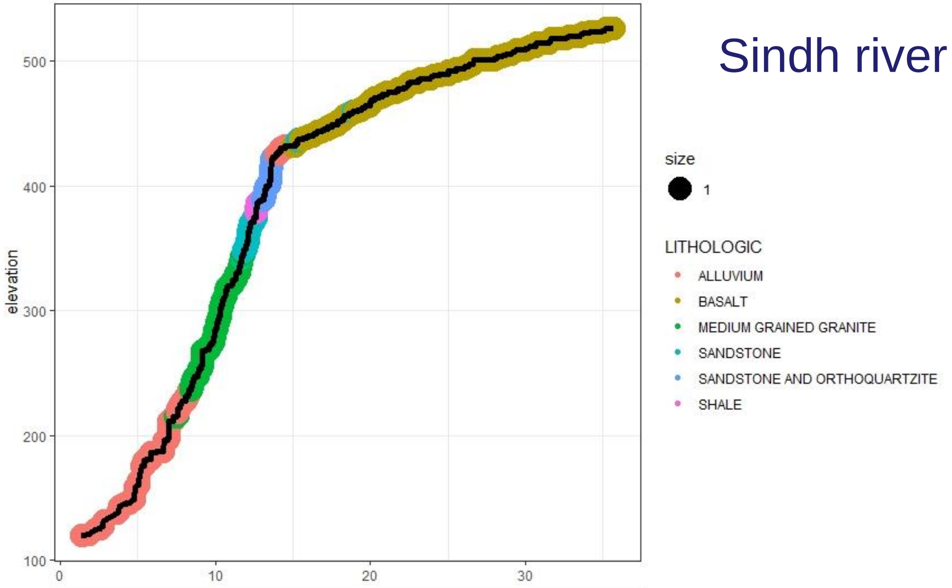
Statistical Summary	
Calculation Method:	Length
Class Interval:	10.0 Degrees
Min.Length Filtering:	Deactivated
Max.Length Filtering:	Deactivated
Azimuth Filtering:	Deactivated
Data Type:	Bidirectional
Population:	38,686
Total Length of All Lineations:	42,039,818.93
Maximum Bin Population:	3,348.0
Mean Bin Population:	2,149.22
Standard Deviation of Bin Population:	604.63
Maximum Bin Population (%):	4.33
Mean Bin Population (%):	2.78
Standard Deviation of Bin Population (%):	0.78
Maximum Bin Length:	2,012,598.74
Mean Bin Length:	1,167,772.75
Standard Deviation of Bin Lengths:	403,657.07
Maximum Bin Length (%):	4.79
Mean Bin Length (%):	2.78
Standard Deviation of Bin Lengths (%):	0.96
Vector Mean:	130.1 Degrees
	310.13 Degrees
Confidence Interval:	5.4 Degrees
	(80 Percent)
R-mag:	0.05


N
Lineaments
Ksn
0- 0.57
0.57 - 0.87
0.87 - 1.28
1.28 - 2.05
2.05 - 156.47
0
750
1,500 m

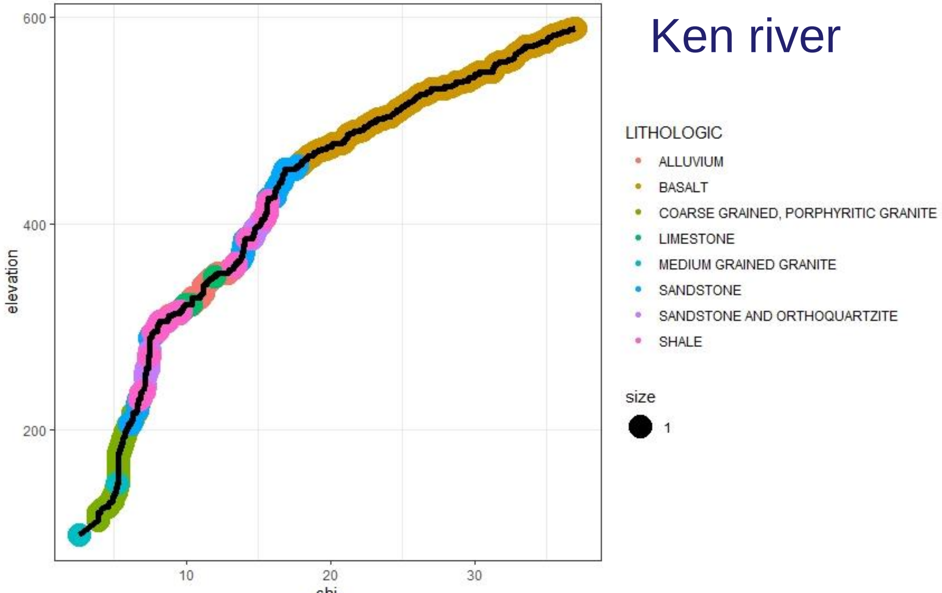
Betwa river



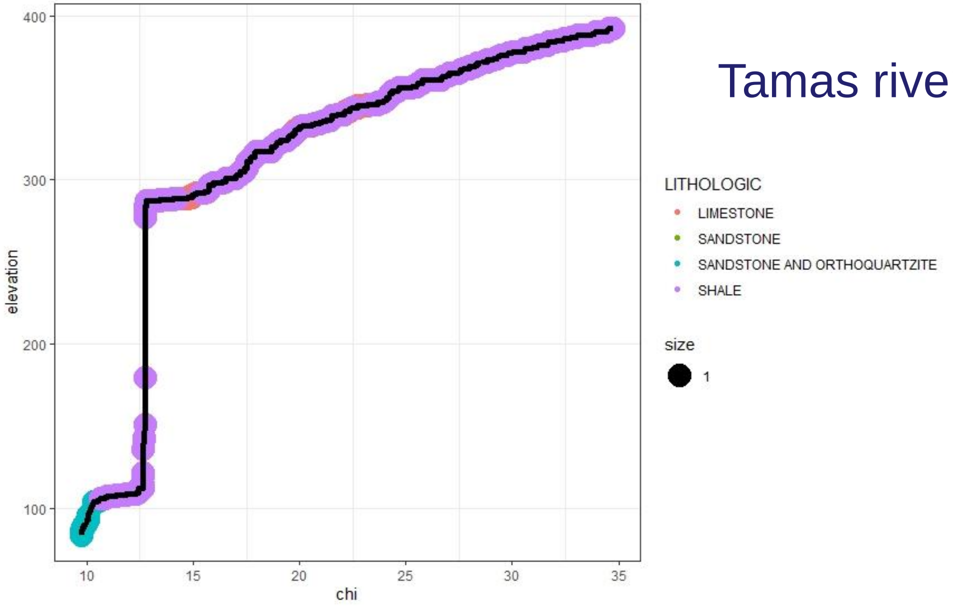
Sindh river



Ken river



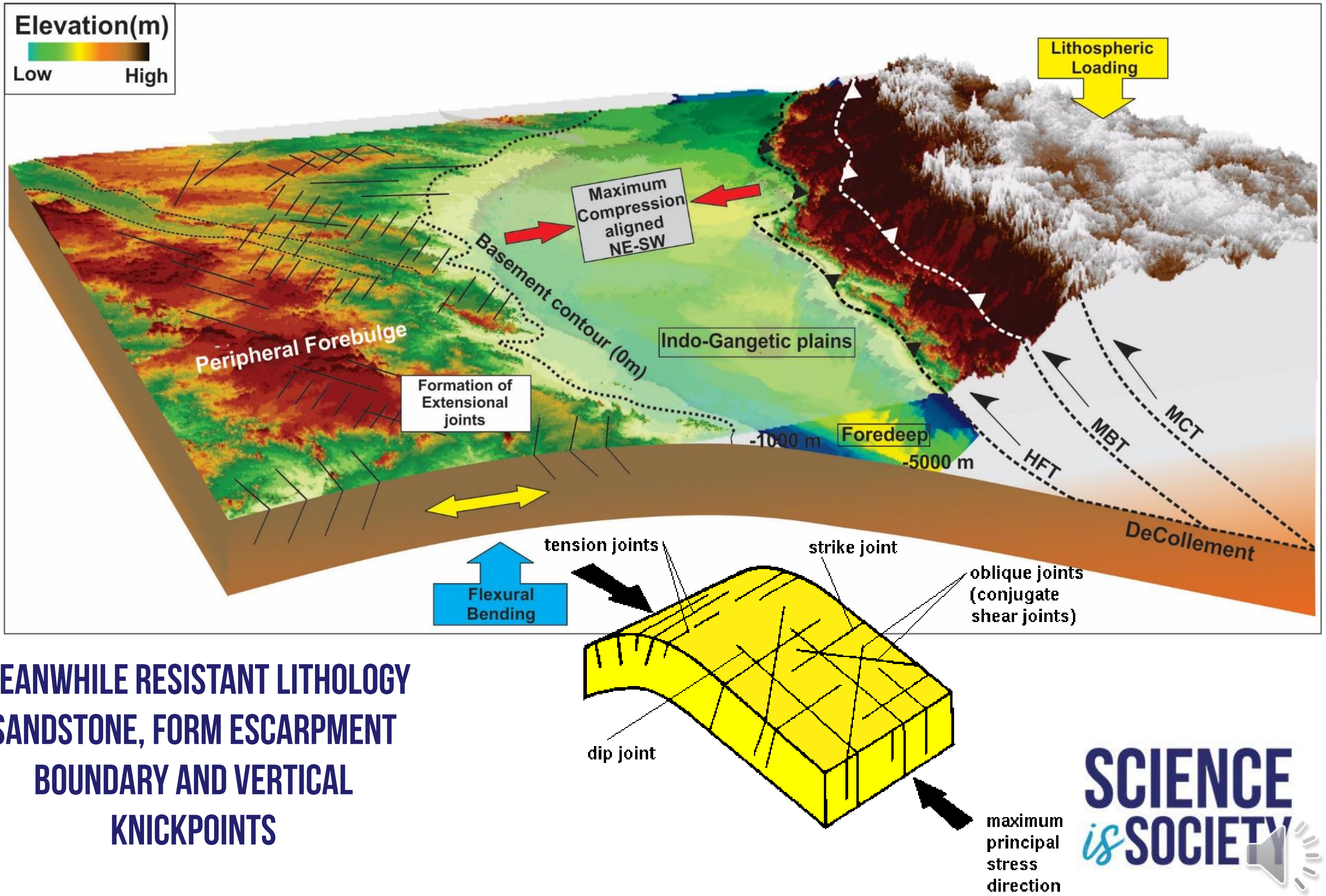
Tamas river



LITHOSPHERIC LOADING IN THE HIMALAYAS CREATED A FLEXURE IN INDIAN PLATE WITH FIBRE STRESS>100MPA

FIBRE STRESSES CREATE LINEAMENTS AND TENSION JOINTS ALIGNED PERPENDICULAR (NW-SE) TO MAXIMUM STRESS DIRECTIONS (NNE-SSW).

LINEAMENTS ACTS AS THE CONDUITS OF FOCUSED EROSION, WHEREAS THE CONTRAST IN THE ROCK STRENGTH CREATE A DIFFERENCE IN FLUVIAL ERODIBILITY RESULTING IN FAST EROSION OF WEAK LITHOLOGIES.



MEANWHILE RESISTANT LITHOLOGY SANDSTONE, FORM ESCARPMENT BOUNDARY AND VERTICAL KNICKPOINTS

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THANK YOU

We conclude that forebulge tectonics and lithological contrast, guides the evolution of landscapes in central India

Questions?

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