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Young Researchers Forum

Paleocurrents and Paleohydraulics studies of the Proterozoic Kolhans vis-a-vis Proterozoic crustal dynamics: a case study from the Chaibasa-Noamundi Basin, Jharkhand, India

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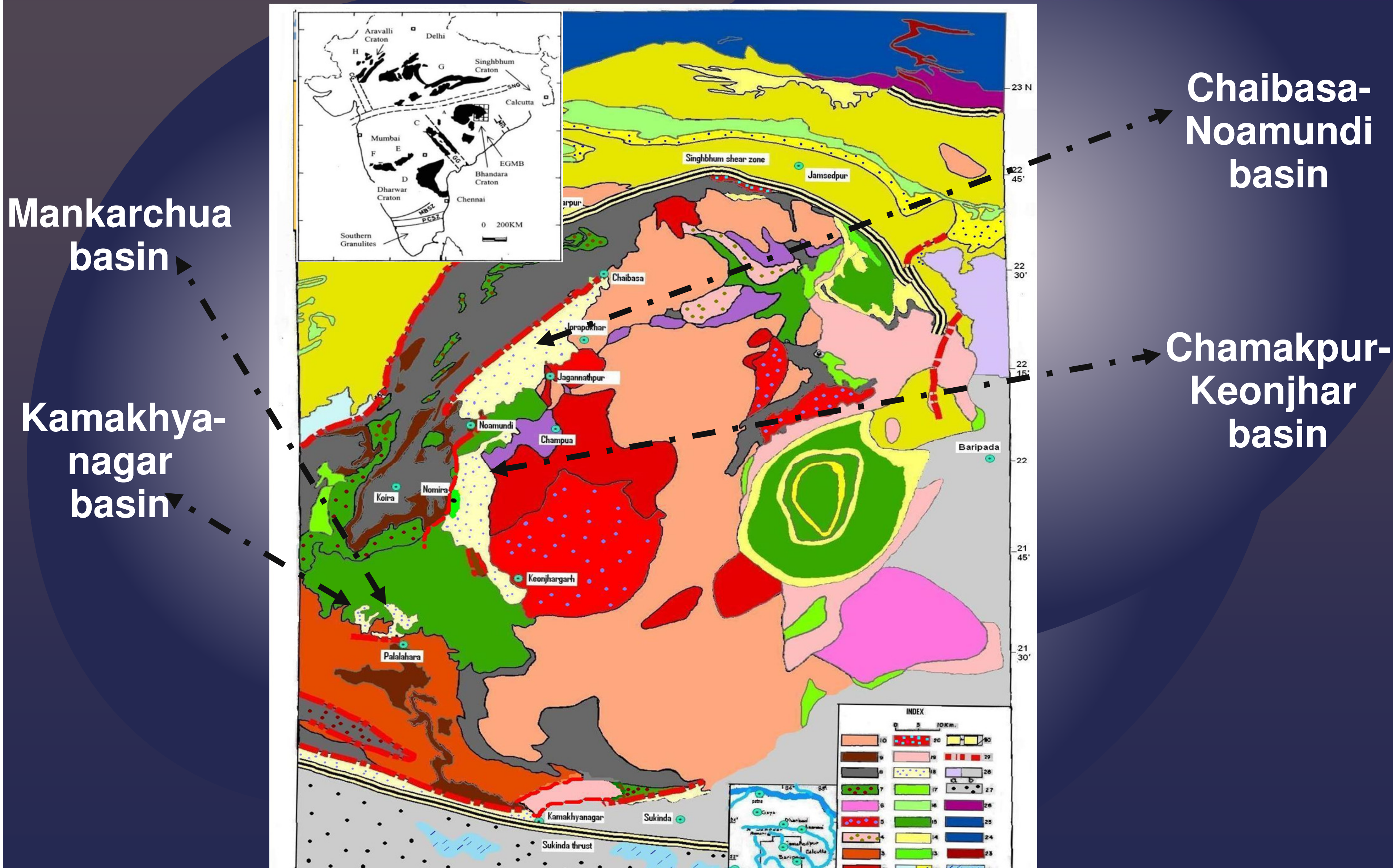
Outline of presentaion

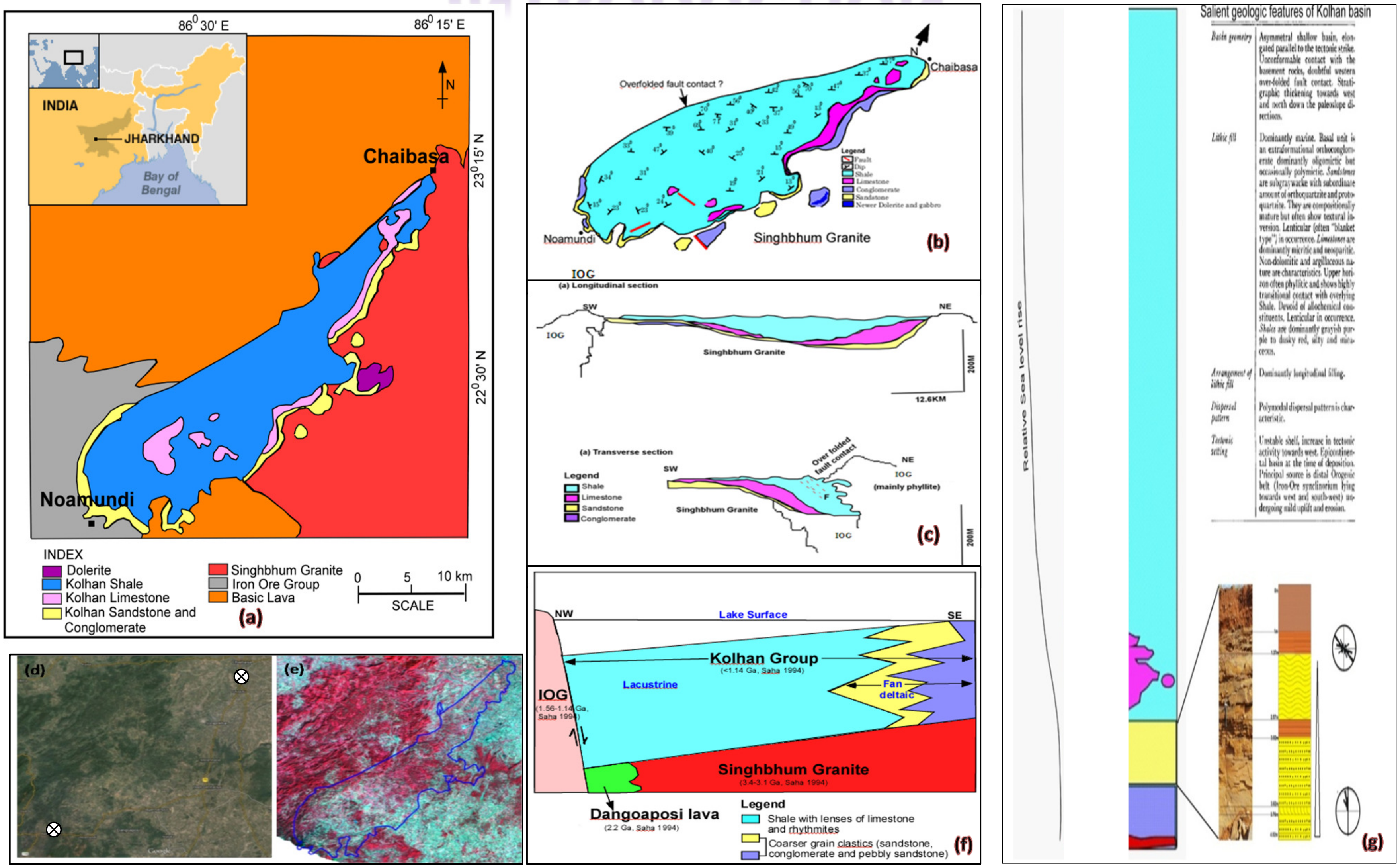
- Introduction
- Objective and organization of the work
- Materials and Methodology
- Result and discussion
- Summary

Kolhan basin



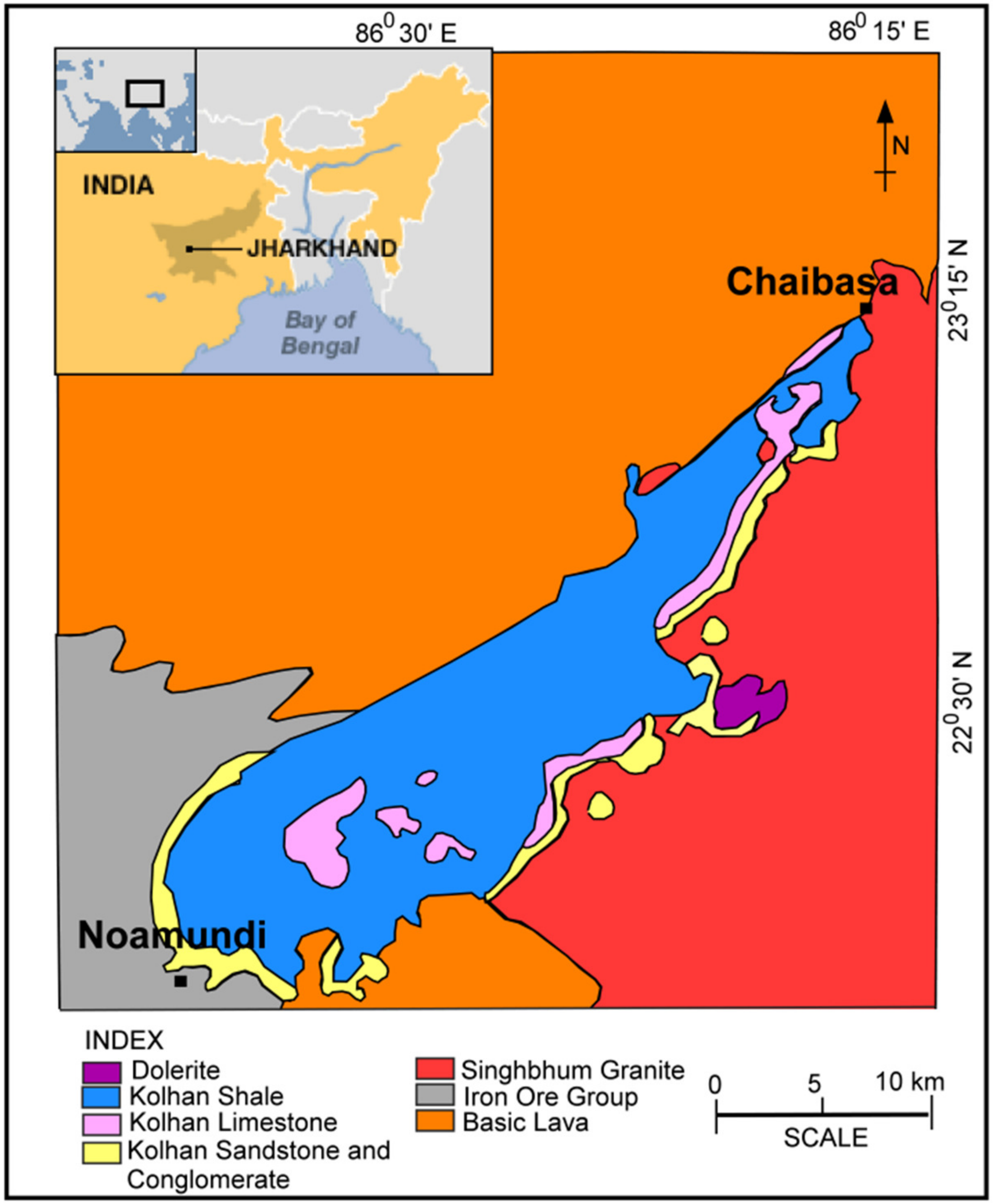
Geological map of Singhbhum-crustal provinces (Saha, 1994)

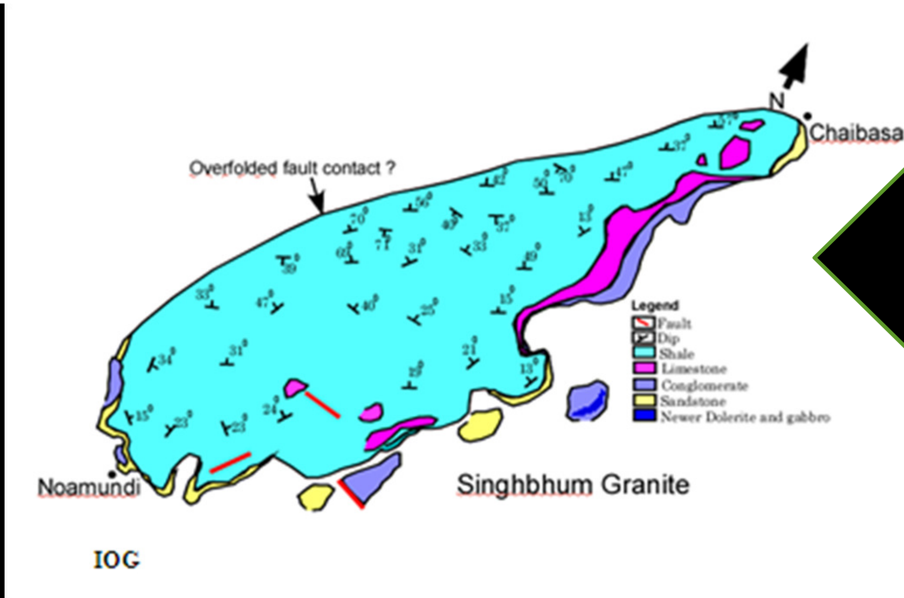
INTRODUCTION



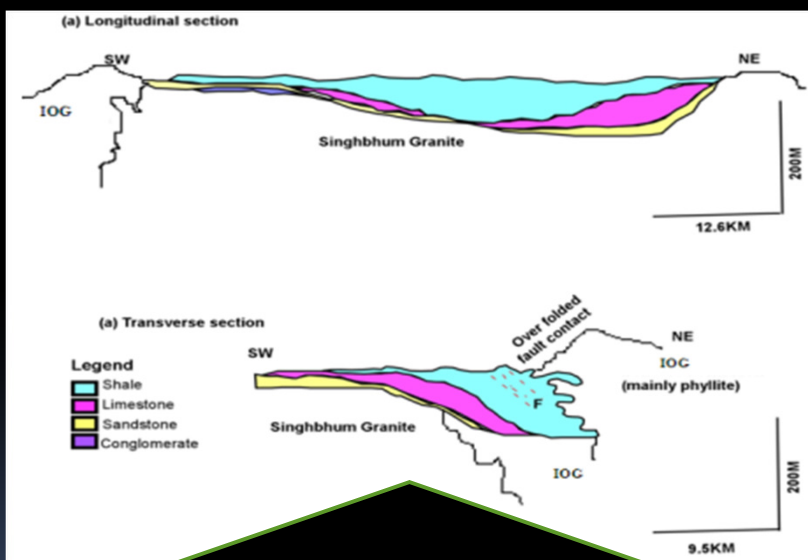
(a) The geological map of Kolhan basin around Chaibasa-Noamundi region (GSI, 2006).(b) Structural map of the Chaibasa-Noamundi basin (Chatterjee and Bhattacharya, 1969) (c) Longitudinal and transverse section along and across the Chaibasa-Noamundi Basin (Sarkar and Saha, 1977), (d) Google earth image showing the study area, (e) LANDSAT-8 image showing the study area, (f) Paleo-environmental sketch showing facies assemblages of Kolhan, (g) A composite log of the Kolhan basin

The geological map of Kolhan basin around Chaibasa-Noamundi region (GSI, 2006)

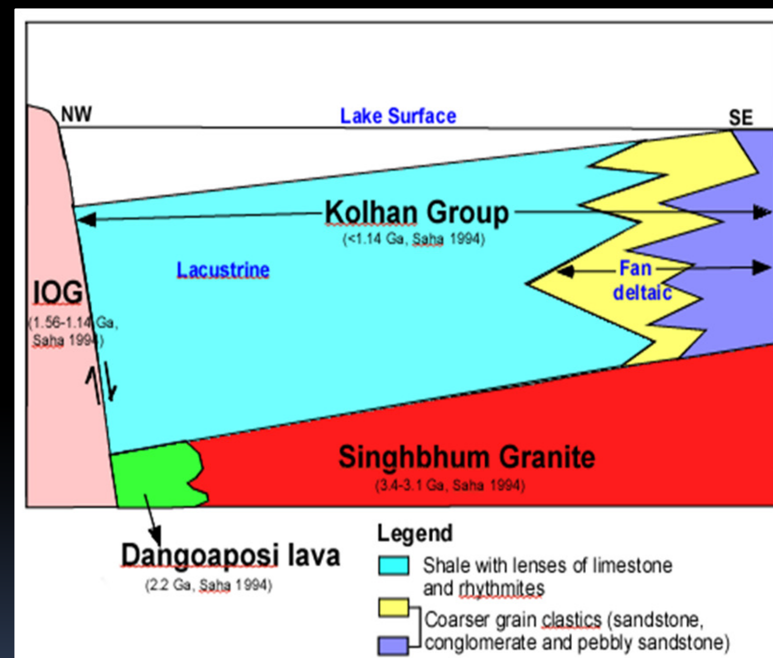




Structural map of the Chaibasa-Noamundi basin (Chatterjee and Bhattacharya, 1969)

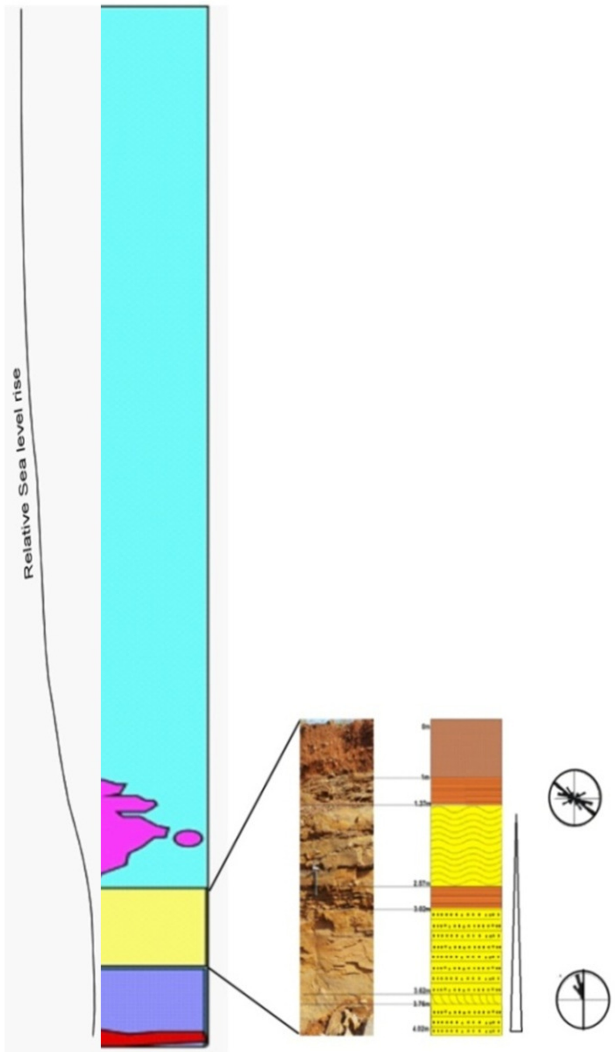


Longitudinal and transverse section along and across the Chaibasa-Noamundi Basin (Sarkar and Saha, 1977)



Paleo-environmental sketch showing facies assemblages of Kolhan

A composite log



Objectives and Organizations

- **Analyses based on logged sections within the Kolhan basin for the paleocurrent data and the petrology of sandstones and conglomerates including heavy minerals studies to interpret provenance and source areas in detail**

- **This study focuses on the detailed provenance evolution of young, post-orogenic extensional grabens to trace the tectonic history of such late-stage basins**



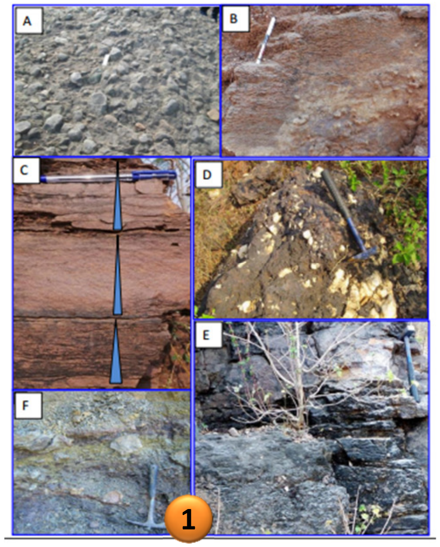
SANDSTONE

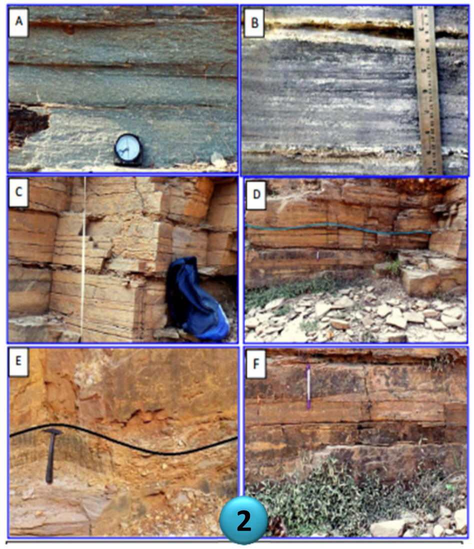


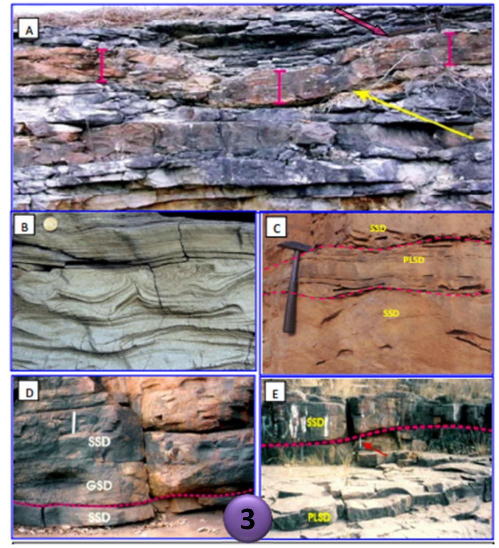
SHALE

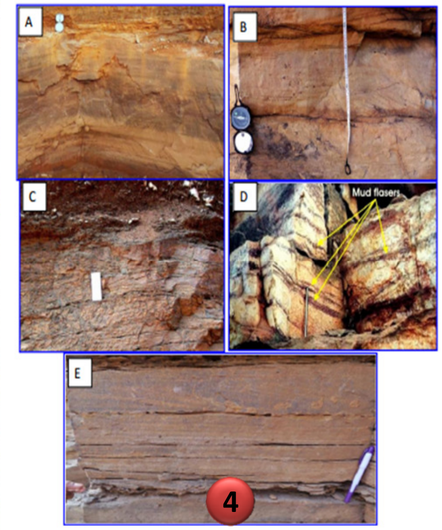
LIMESTONE

Sedimentary structures expressed as percentages

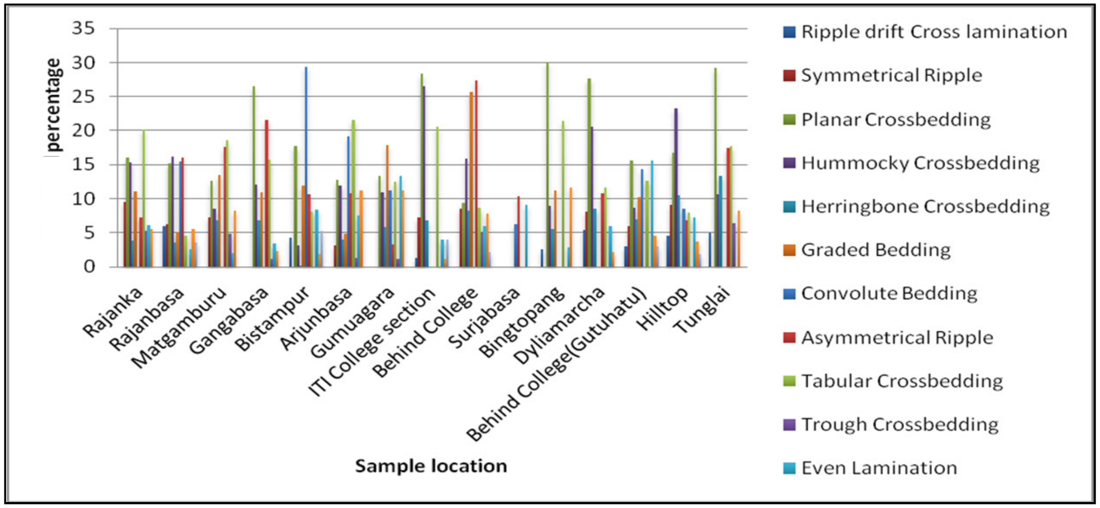








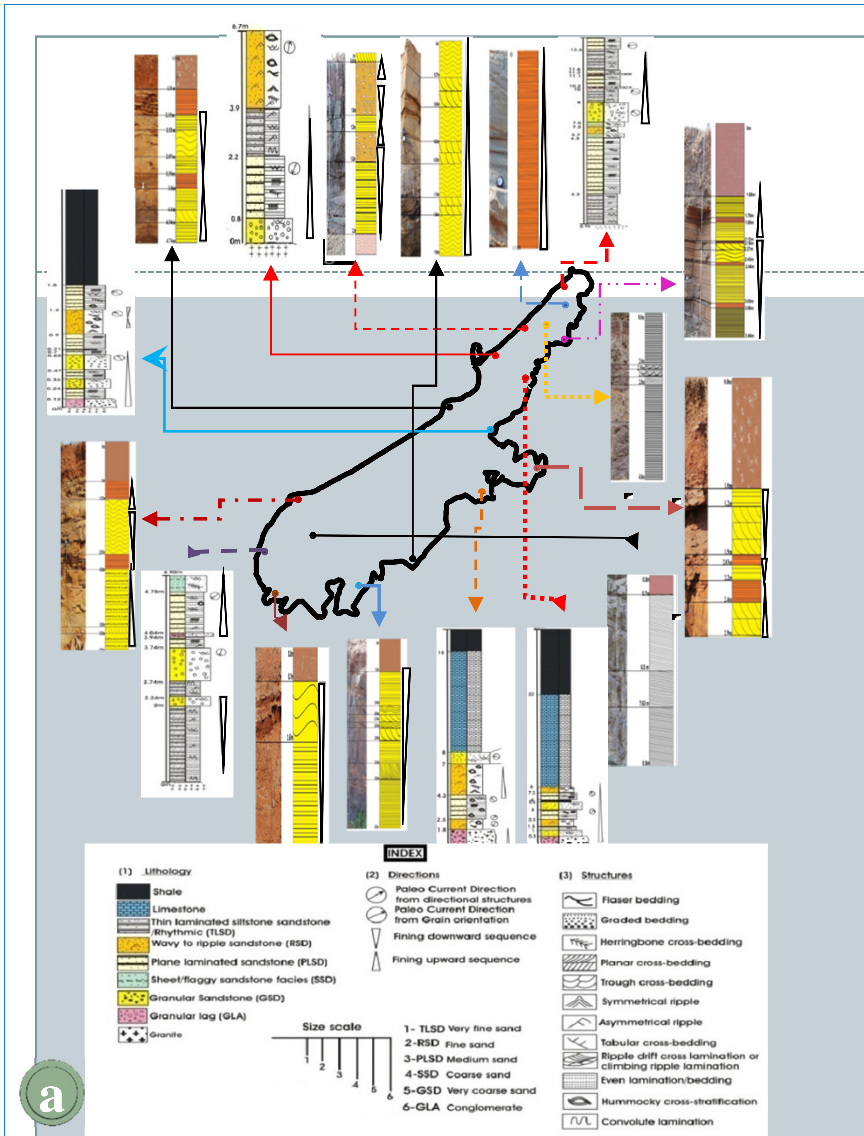
1 **(A)** Polymict conglomerate**(B)**Scour and fill structure in sheet sandstone.**(C)** Rhythmic fining upward gradation in granular sandstone.**(D)** Crudely stratified conglomerate.**(E)** Matrix supported conglomerate showing normal grading with poorly defined stratification (GLA facies). **(F)** Exposure of matrix supported conglomerate with ripped-up large clast (GLA facies) 2 **(A-C)** Horizontal and parallel laminations in PLSD facies. **(D&E)** Mega wavy bedding (PLSD facies). **(F)** Wave induced asymmetrical ripples 3 **(A)** Intraformational slumps (PLSD facies) **(B)** Convolute lamination (SSD facies). **(C)** Alternated layers of sheet sandstone facies (SSD) and plane laminated sandstone facies(PLSD) (Note : the contact between SSD and PLSD is marked by megarippled bed form). **(D)** Alternated layers of sheet sandstone facies (SSD) and granular sandstone facies (GSD) (Note : the contact between SSD and GSD is marked by megarippled bed form). **(E)** Wavy erosional contact between SSD and PLSD facies 4 **(A)** **P**lanar cross-laminae **(B)** Trough cross-stratifications (RSD facies) **(C)** Herringbone cross-bedding in SSD facies **(D)** Mud flasers and laminated mud occurring as draped surface over ripple forms (RSD facies) **(E)** Tabular cross-bedding in GSD facies

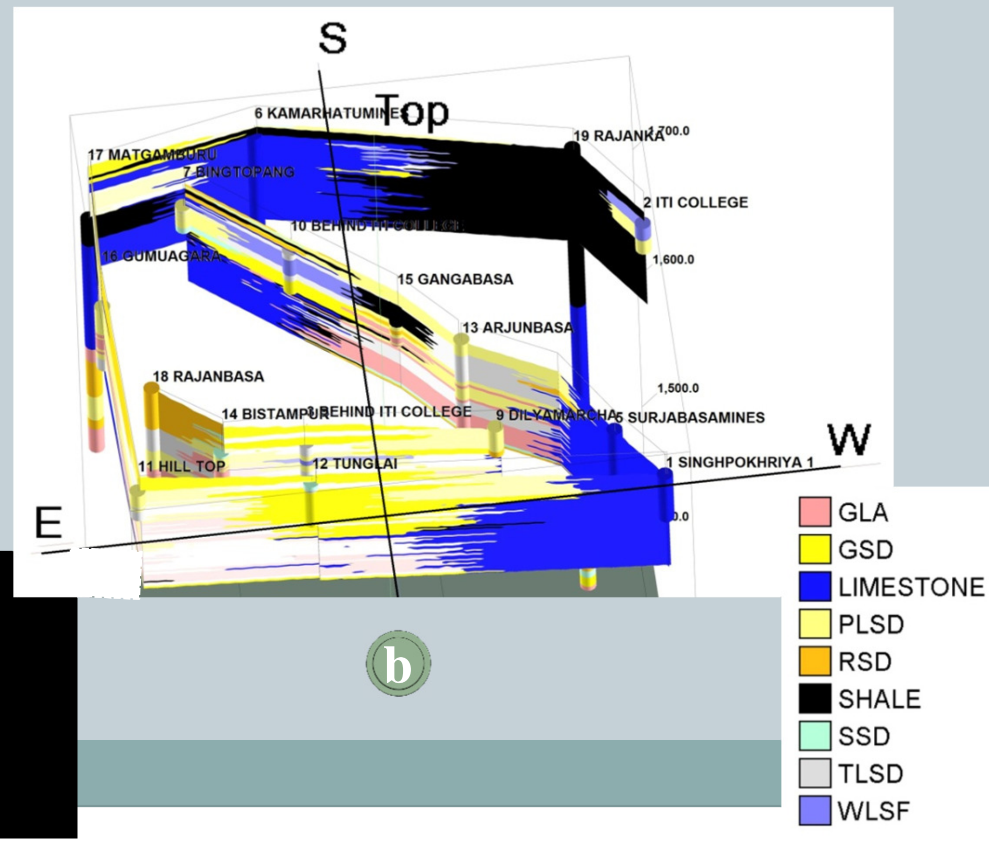


➢Structures generated by flat beds are comparatively more noticeable than structures related to the bedform migration

(a)Lithologs showing the vertical distribution of the lithofacies in the study area, (b) Panel diagram for seventeen lithologs

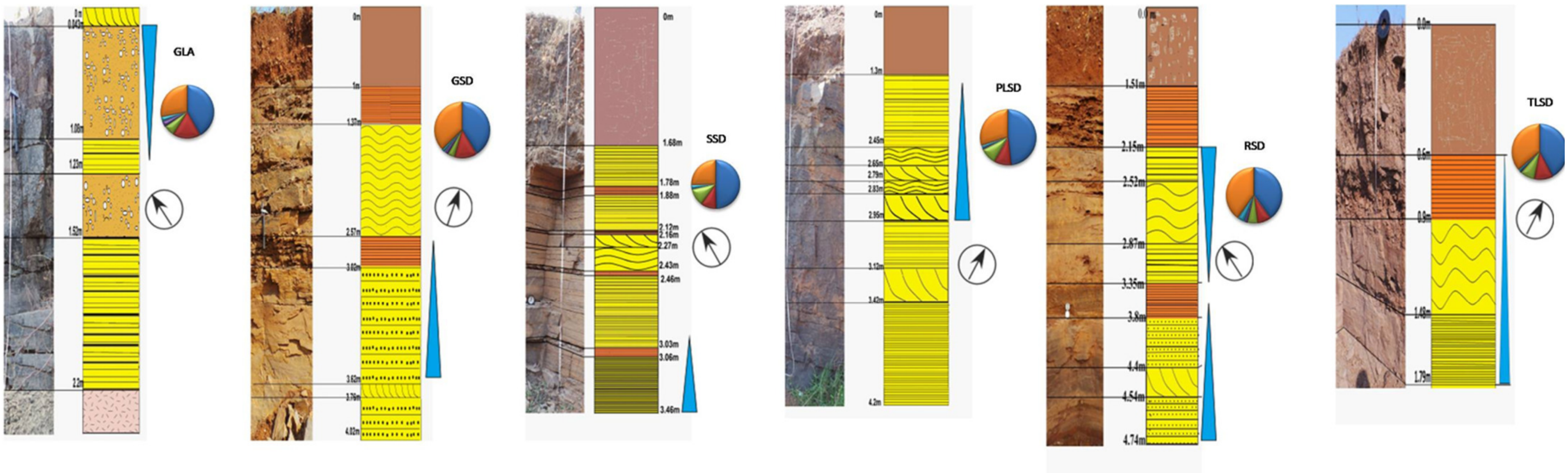
- Granular lag facies (GLA)
- Granular sandstone facies (GSD)
- Sheet sandstone facies (SSD)
- Plane laminated sandstone facies (PLSD)
- Rippled sandstone facies (RSD)
- Thin laminated sandstone facies (TLSD)





Lithofacies analyses

Columnar sections measured in Kolhan basin showing the paleoflow direction and percentage of heavy mineral composition and ZTR plot from six different locations



INDEX

(1) Lithology

- Pebbly sandstone
- Sheet sandstone
- Granite
- Crossbedded sandstone
- Soil
- Rhythmite
- Plane laminated sandstone
- Wavy laminated sandstone
- Granular sandstone

(2) Direction

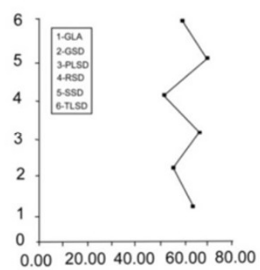
- Paleo Current Direction
- Fining downward sequence
- Fining upward sequence

Size scale

1- TLSD Very fine sand
2-RSD Fine sand
3-PLSD Medium sand
4-SSD Coarse sand
5-GSD Very coarse sand
6-GLA Conglomerate

(4) Heavy Minerals

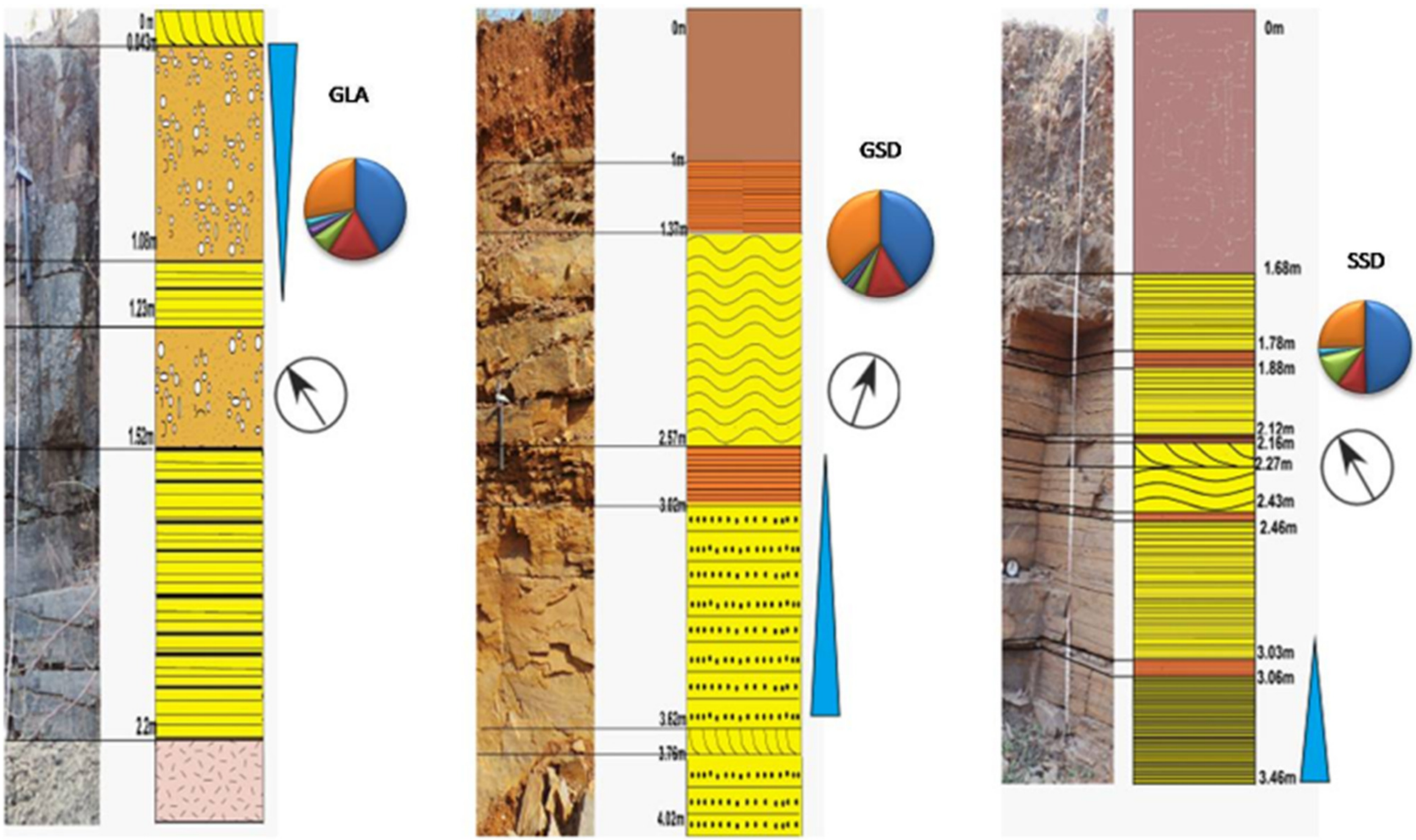
- Zircon
- Tourmaline
- Rutile
- Sphene
- Garnet
- Opaques



(5) Plots of ZTR index (zircon-tourmaline-rutile index, Pettijohn, 2004) of sixlithofacies

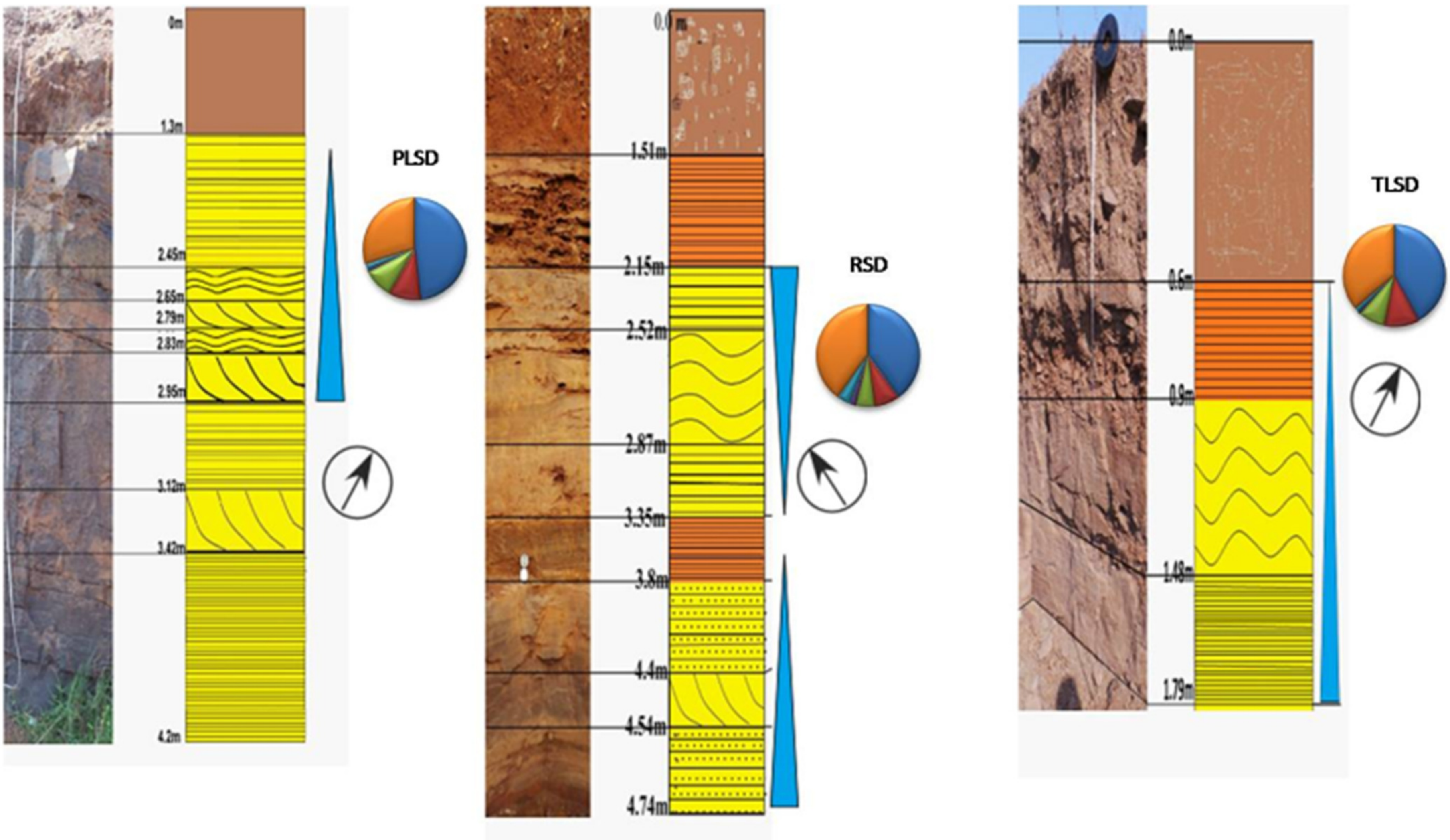
Locations: Rajanka, Arjunbasa, Bistampur, Matgamburu, Gangabasa and Rajanka (from left to right)

Columnar sections measured in Kolhan basin
showing the paleoflow direction and percentage of heavy mineral composition and
ZTR plot from six different locations



Locations: Rajanka, Arjunbasa, Bistampur,

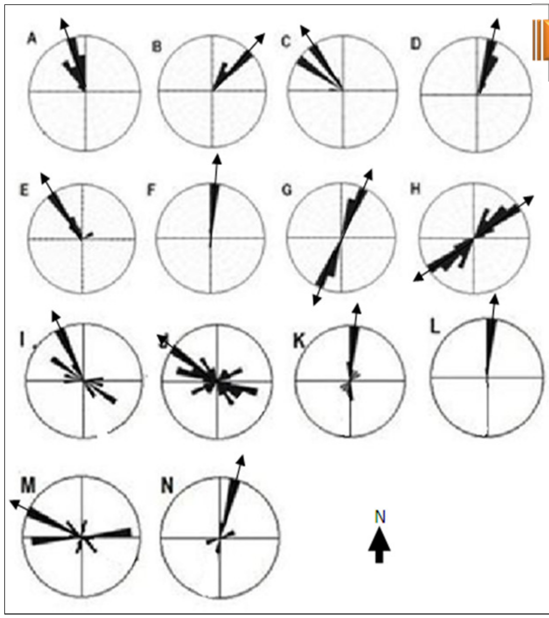
Columnar sections measured in Kolhan basin
showing the paleoflow direction and percentage of heavy mineral composition and
ZTR plot from six different locations



Locations: Matgamburu, Gangabasa and Rajanka

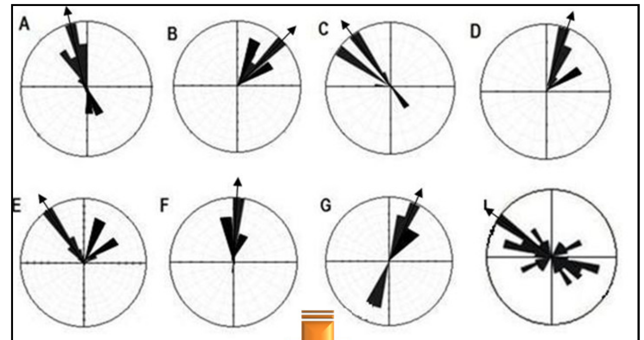
Paleocurrent analyses

from cross bed



Location	*No. of data*	*Class intervals*	*Vector mean in Degrees*	*95% confidence intervals in Degrees*
A	*70*	*10*	*338*	*7.2*
B	*55*	*10*	*36.2*	*4.1*
C	*40*	*10*	*311*	*10.2*
D	*78*	*10*	*23*	*5.6*
E	*50*	*10*	*339*	*10.2*
F	*68*	*10*	*3*	*29.9*
G	*54*	*10*	*19 and 199*	*4.3*
H	*47*	*10*	*46 and 226*	*13.7*
I	*48*	*10*	*318*	*36*
J	*51*	*10*	*294*	*38*
K	*58*	*10*	*12.2*	*12*
L	*44*	*10*	*06.2*	*6*
M	*50*	*10*	*291*	*19*
N	*47*	*10*	*28.2*	*33*

from grain orientation

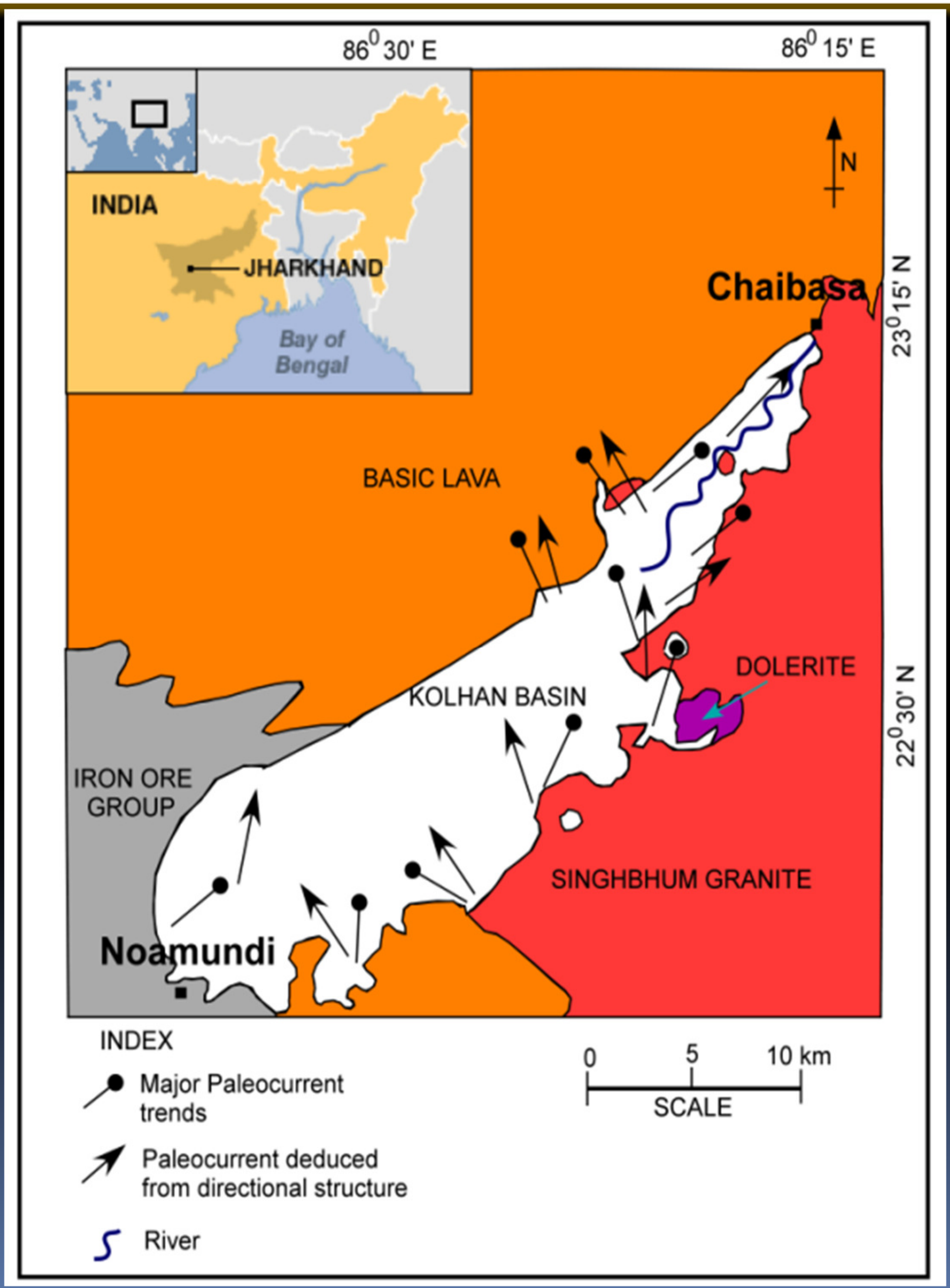


Location	No. of data	Preferred Orientation direction	Linear Arithmetic mean (in degrees)	Circular arithmetic mean (in degrees)
A	47	332	201.80	255.88
B	38	33.9	176.62	193.35
C	43	309	205.56	300.26
D	49	28	169.89	285.95
E	31	342	171.00	275.41
F	37	2	192.48	305.04
G	46	22	193.44	302.05
H	34	314	159.61	290.24

(A)Behind ITI Section, (B) Surjabasa Section, (C) Bingtopang Section, (D) Gumuagara River Section, (E) Dyliamarcha Section 1st, (F) Hill top, (G) Tunglai Section, (H) Dyliamarcha Section 2nd , (I) Gangabasa section, (J) Pungsiya section, (K) Bistampur section, (L) Tunglei (M) Matgamburu section, (N) Rajanbasa section

(Following standard methods of Shelly 1968, Middle Ton 1965, Potter 1965)

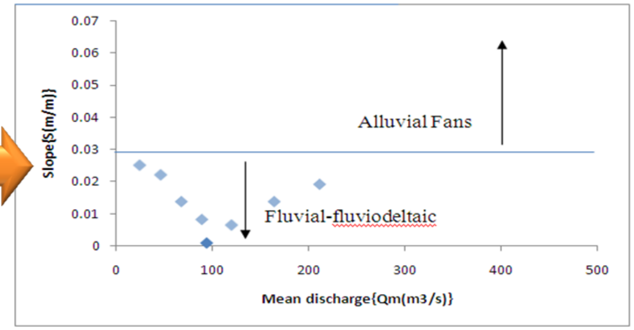
A synoptic view of the paleocurrent dispersal pattern in the study area

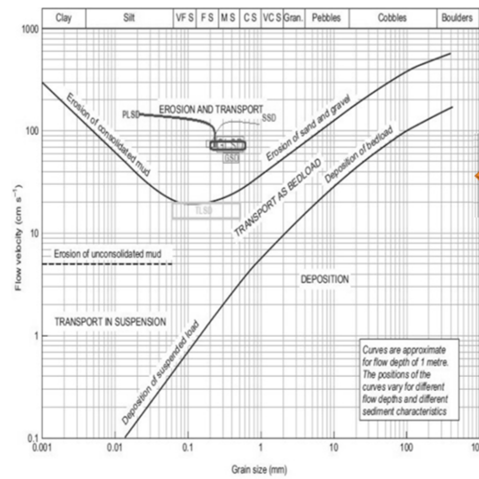


Paleohydraulic analyses

Estimates of Paleohydrologic Parameters of the Study Area	
Parameters	Mean Estimate
Mean cross-bed set thickness	0.13 m
Mean water depth (d_s)	1.38 m
Channel width (w)	61.59 m
Width/depth ratio (F)	42.97
Meander wavelength (L_m)	701.26 m
Mean annual discharge (Q_m)	94.34m^3/s
Channel slope (S_c)	0.00084
Flow velocity (v)	0.66m/s
Froude number (F_r)	0.20

Binary plot of palaeoslope (S) and mean annual discharge values (Qm)

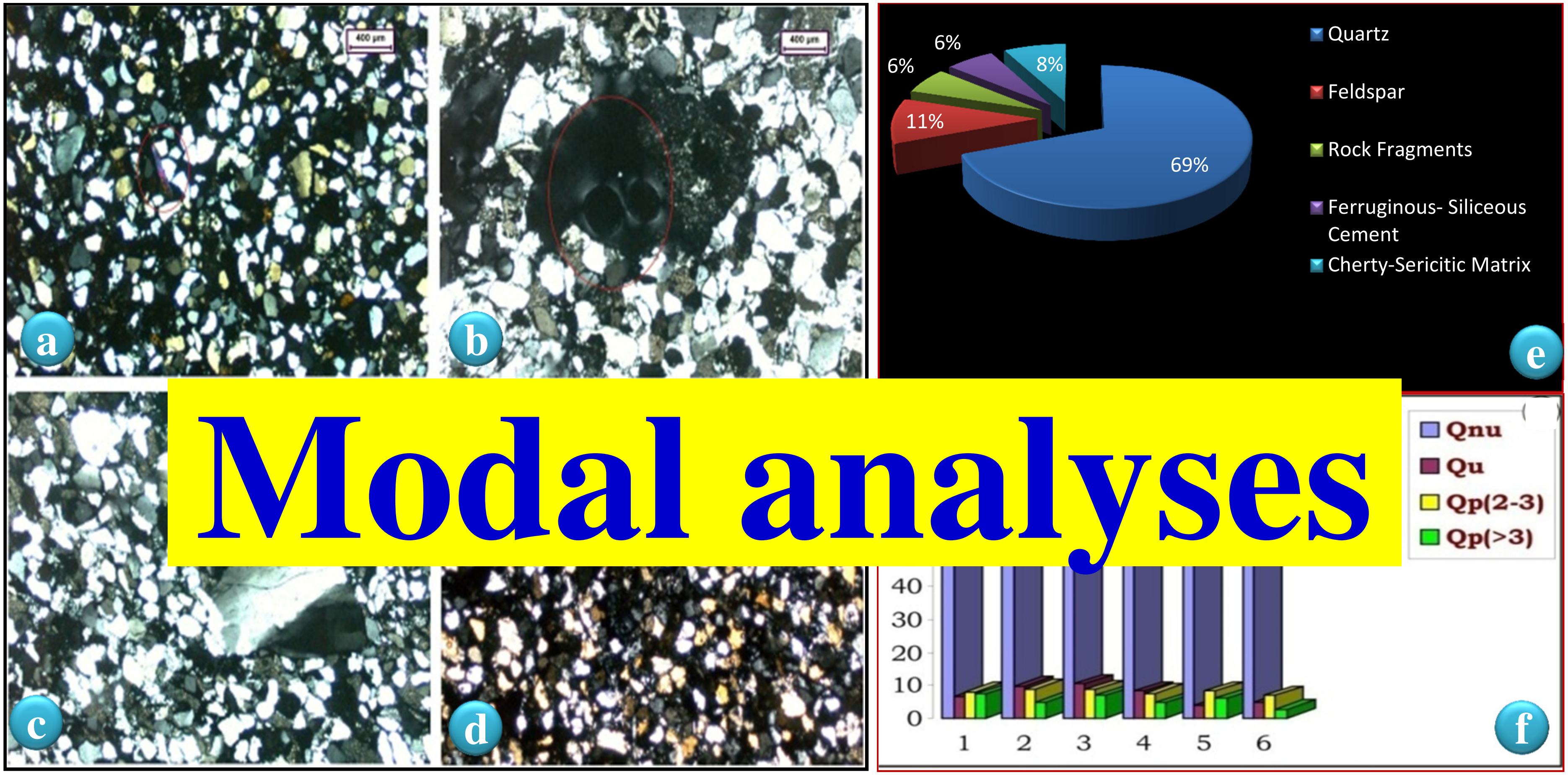




Hjulstorm's diagram showing relationship among erosion, transportation and deposition of sedimentary particles

➢The dispersal of sediments was from the southwest and southeast directions, and the Iron Ore Group and Singhbhum granitoid terrains may be the source rock for the Kolhans (Ethridge and Suhumm 1978, Yalin 1978)

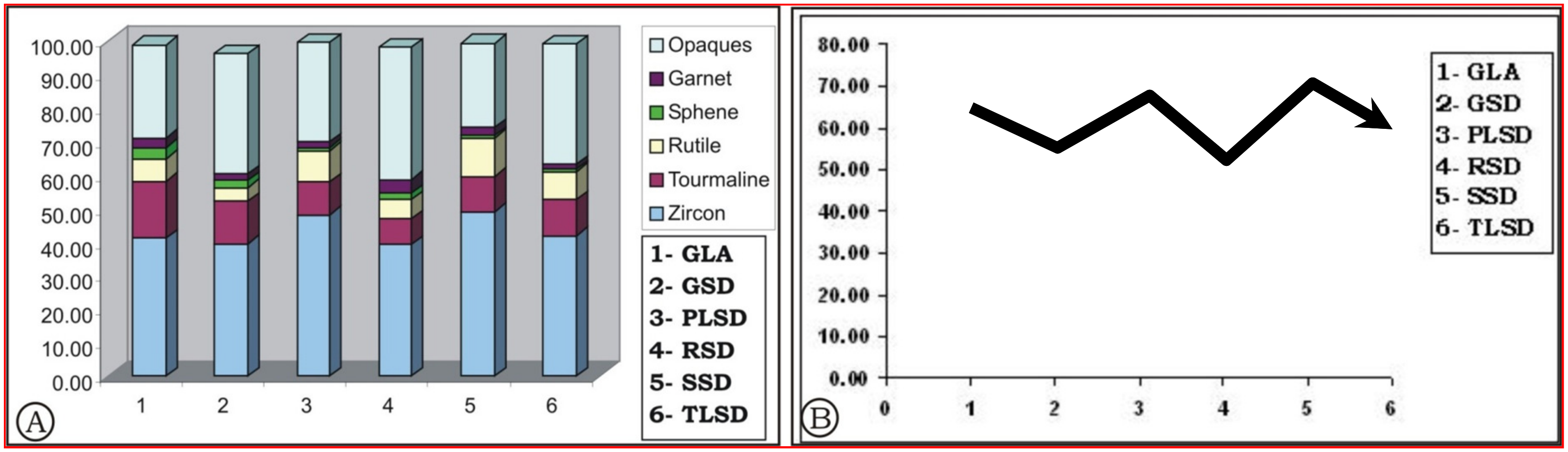
Modal analyses



(a) Undeformed rounded monocrystalline framework quartz grains (b)Moderately well sorted, medium-coarse grained sandstone (c) Quartz grains showing bimodal distribution in quartz arenite, (d) silica overgrowth (e) Modal analyses of 105 fine to medium-grained texturally mature to submature samples (f) Quartz type percentage

- Few of the immature sandstones show textural inversion
- Quartz is the dominant constituent framework grain, and monocrystalline quartz predominates over polycrystalline quartz

Heavy mineral assemblages

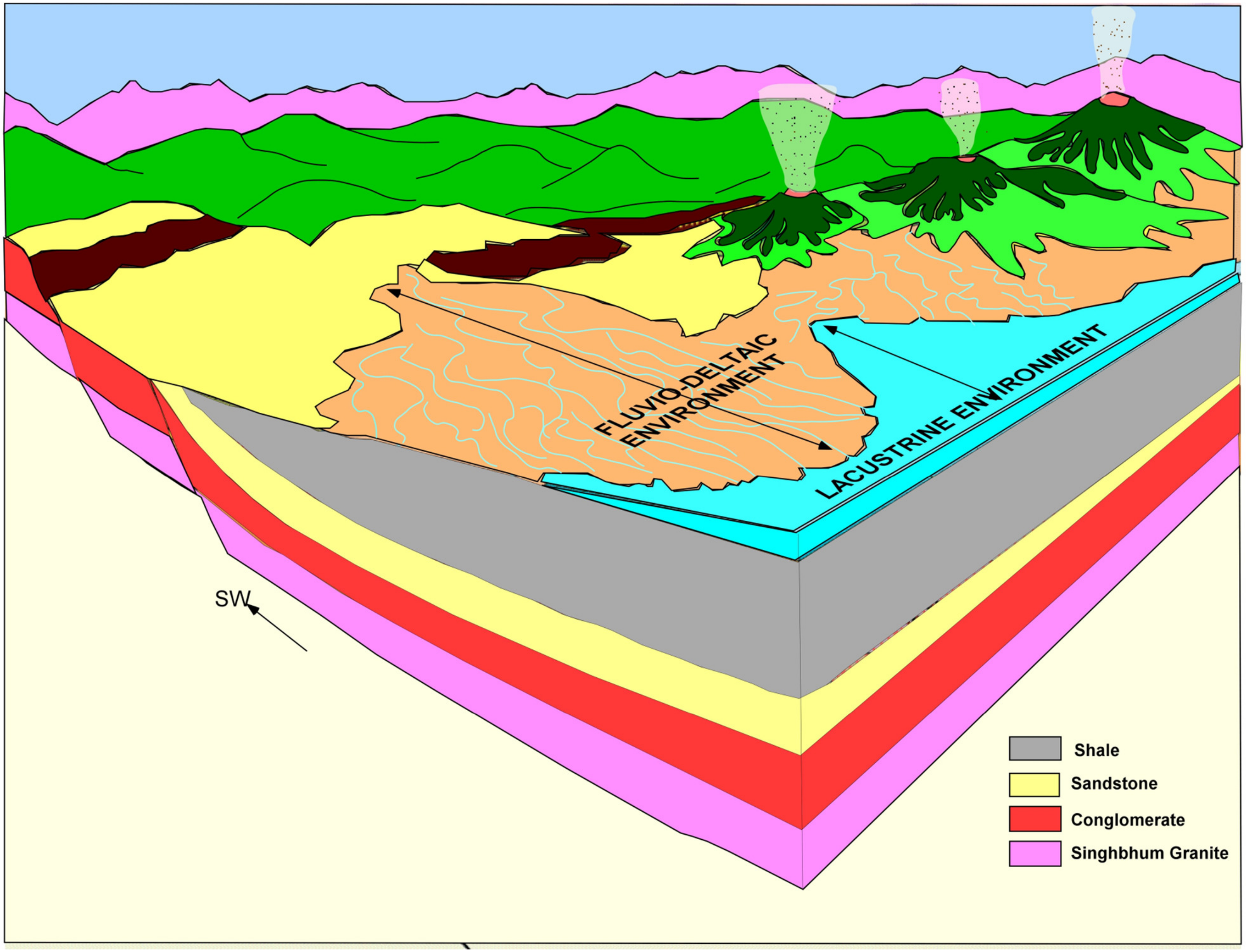


(A) Bar diagrams showing the percentage distributions of the heavy minerals in different facies **(B)** Plots of ZTR index of six lithofacies

➢**Heavy mineral fraction varies from 0-3.25 % by weight**

➢**Consistent size & shape of heavy minerals suggests mostly those are derived from the Singhbhum granite and also partly from Iron Ore Group**

Basin Model


FLUVIO-DELTAIC ENVIRONMENT
LACUSTRINE ENVIRONMENT
SW
Shale
Sandstone
Conglomerate
Singhbhum Granite

Conclusions

- Paleocurrent study reveals that the low channel sinuous flow that advanced persistently from the north-northeast to a north- northwest direction along a palaeoslope, which remained unchanged throughout the deposition of the Kolhans

- The Kolhan basin was filled by fluvial system, which was individually about 61.59m wide and 1.38 m deep. The river had a low sinuosity developed channels mostly in a north-northwest direction with flow velocity between 0.66 m/s. On the basis of uniformity in the paleocurrent directions, it is inferred that the basin continued north and westward down the paleoslope

- The Kolhans were deposited in half-graben basins formed during the early rifting stage of the Singhbhum craton. This formation consists of fluvial, and lacustrine sequences that were deposited under arid-humid climatic conditions.

Conclusions

- Lacustrine deposition took place in a topographic depression adjacent to the basin margin. The presence of alluvial-fan and fluvial or lacustrine deposits in vertically stacked sequences indicates that the basin topography changed through time

- The lacustrine or fluvial environments responded more quickly to periods of tectonic subsidence and migrated over the fans to occupy the basin-margin depression

- Aided by a decrease in basin subsidence, the fans eventually prograded and displaced the lacustrine environments away from the basin margin and more towards the Iron Ore Group margin

Bibliography

- Bhatia M. R. (1983). Plate tectonics and geochemical composition of sandstones. J Geol: 91, pp. 611–27.
- Bjorlykke, K. (1974). Geochemical and mineralogical influence of Ordovician island arcs on epicontinental elastic sedimentation. A study of Lower Paleozoic sedimentation in the Oslo region, Norway. Sedimentology 21, 251-72.
- Dickinson, W. R. (1985). Interpreting provenance relations from detrital modes of sandstones. In Provenance of Arenites (ed. G. G. Zuffa), pp. 333-61. Dordrecht: D. Reidel.
- Englund, J.-O. & Jorgensen, P. (1973). A chemical classification system for argillaceous sediments and factors affecting their composition. Geologiska Foreningens Stockholm Fohandlingar 95, 87-97.
- Folk, R. L. (1980). Petrology of Sedimentary Rocks. Austin, Texas: Hemphill Publication Company, 182 pp.
- Geological Map of West Singhbhum District, Jharkhand, India, GSI, 2006

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Field Visit


THANK YOU