

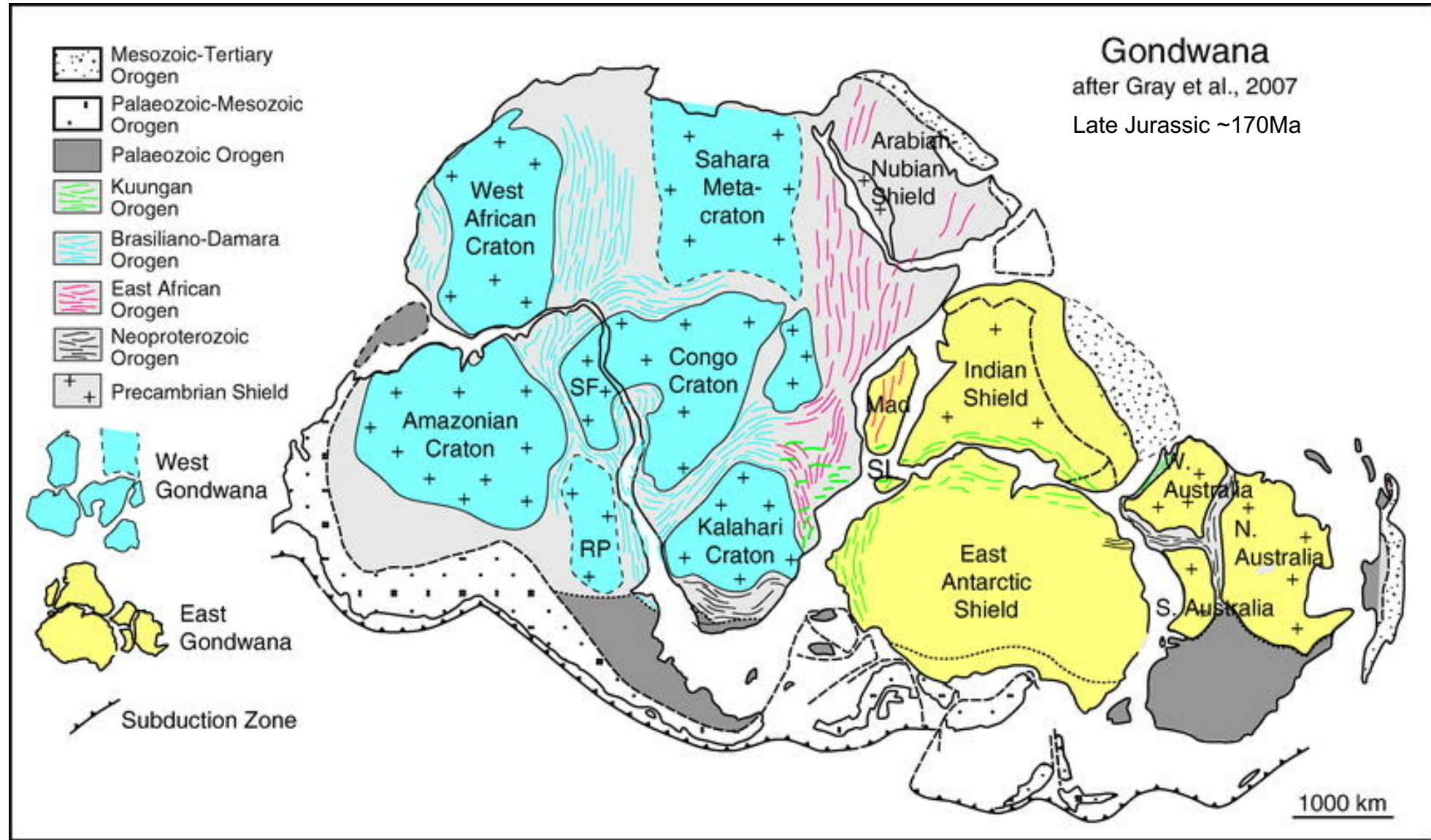
# 16-10: Provenance Variation in Permo-Carboniferous Siliciclastic Sequences from Central-Eastern Indian Platform

Sharif Mustaque, Ashraf Uddin and Willis E. Hames

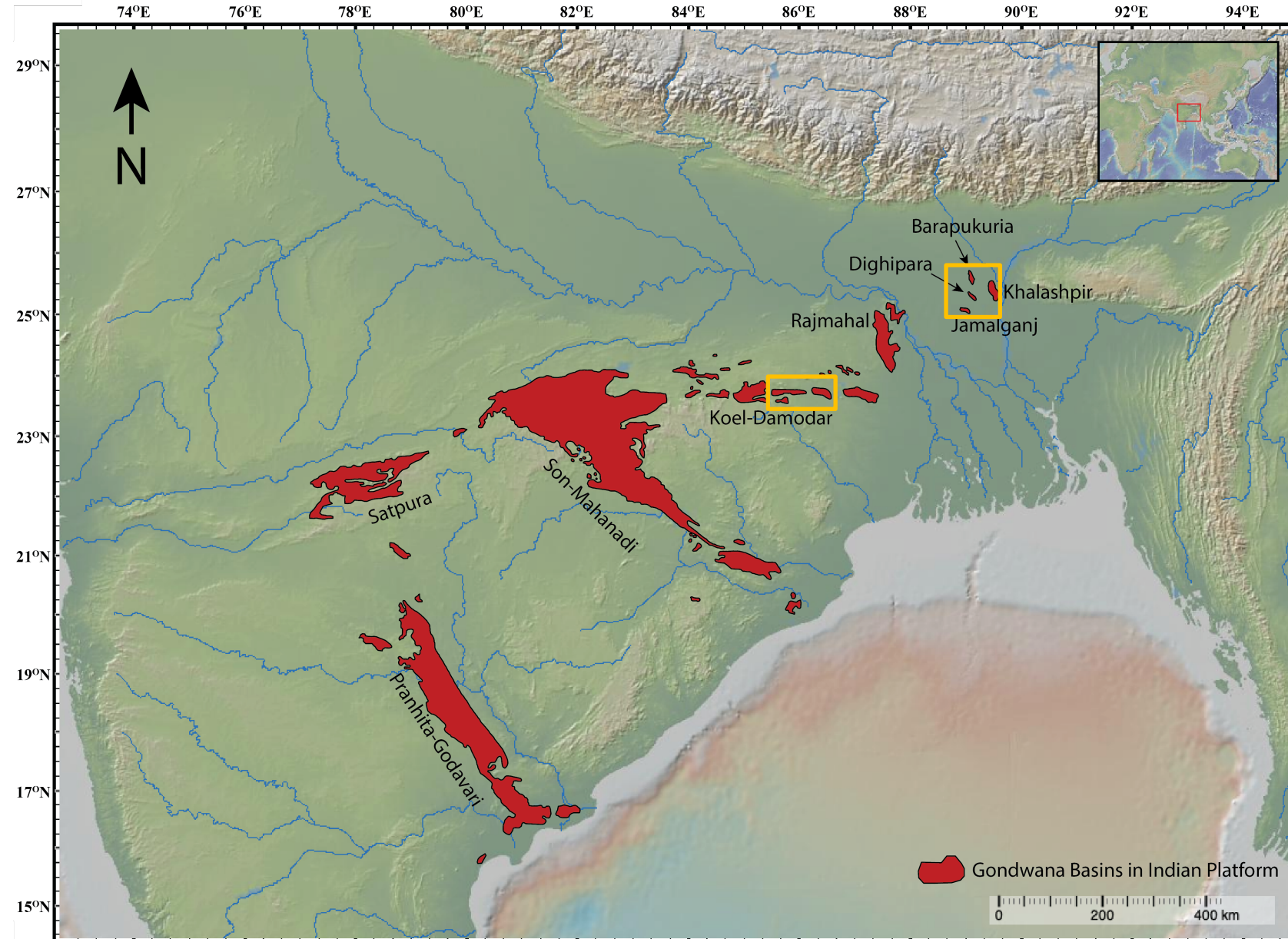


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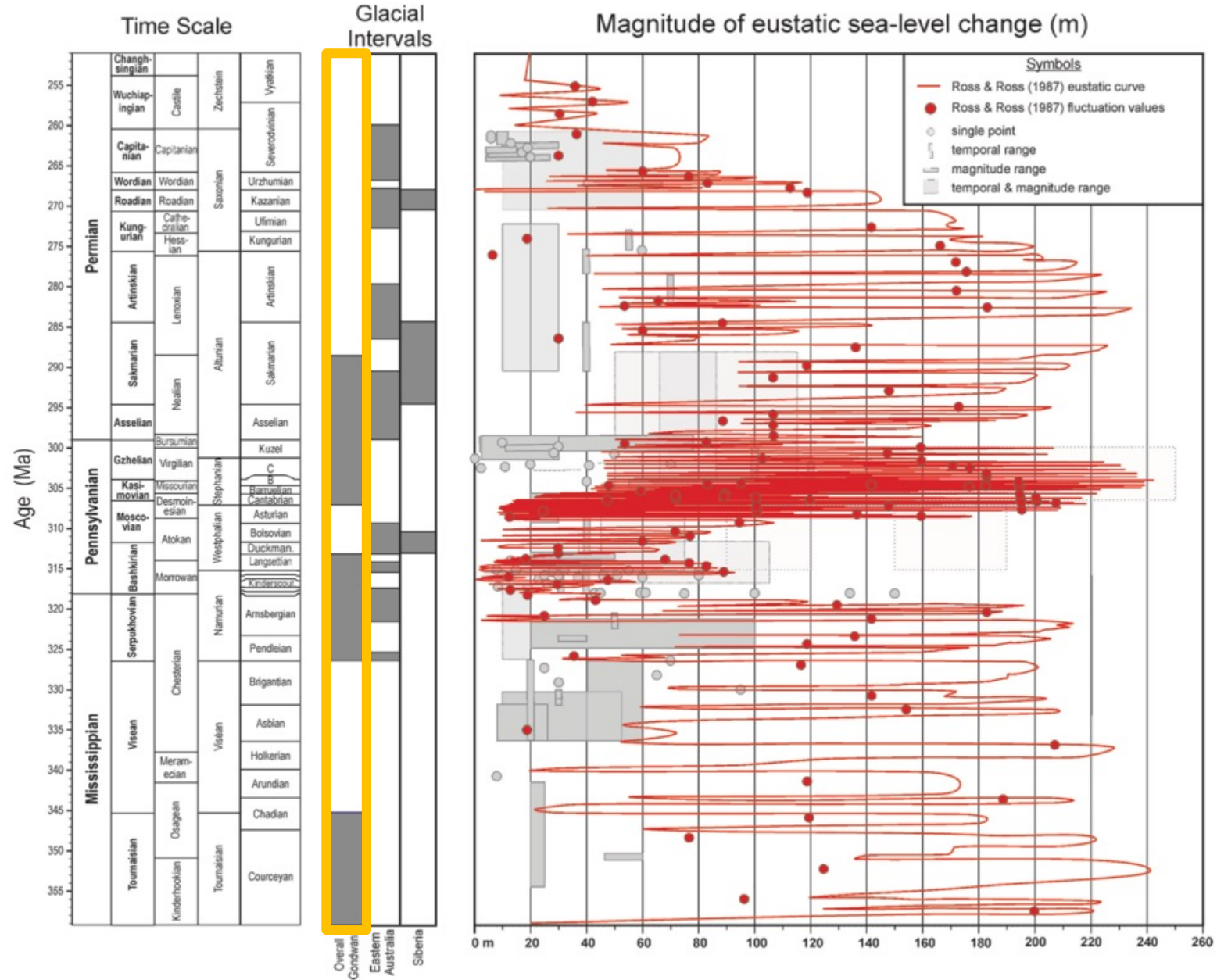
- Preface
- Methodology
- Results
- Discussion
- Conclusion



- **Provenance** study of Gondwana sediments in the **Indian platform** to observe changes in **tectonic setting** and possible **source terranes**.
- Impact of **climatic variation** in **sediment disposal pattern** in these basins.
- Understand **fluvial dynamics** throughout the sediment deposition and basin evolution.

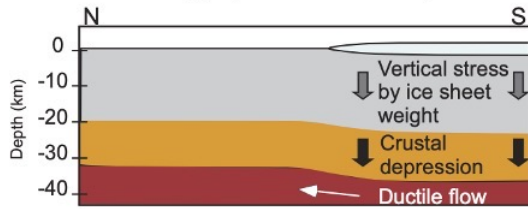




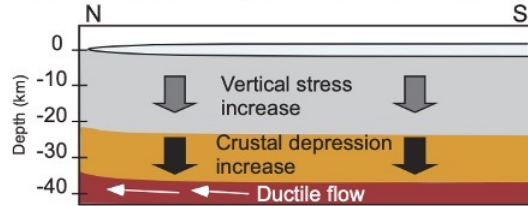




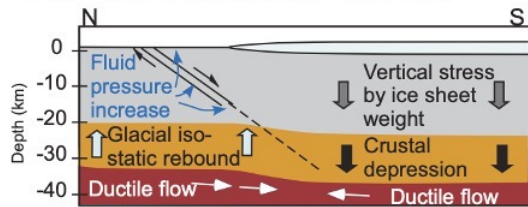
a Gzhelian stage (299Ma - 303Ma)



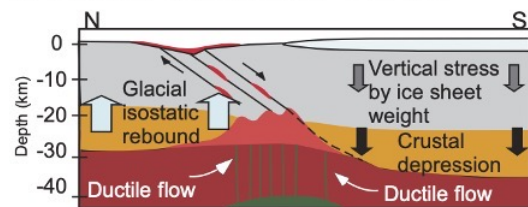
b Asselian to Sakmarian stage (290Ma - 299)



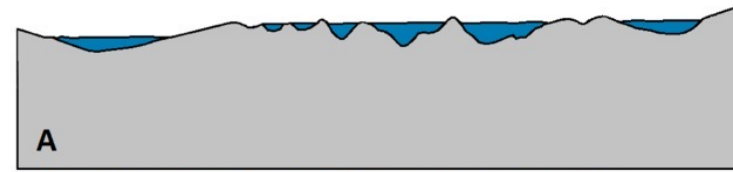
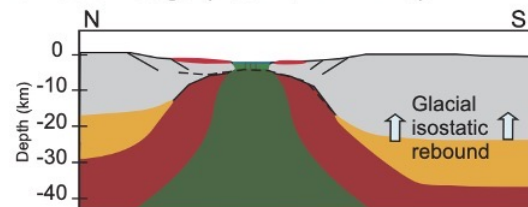
c Artinskian stage (280Ma - 290 Ma)



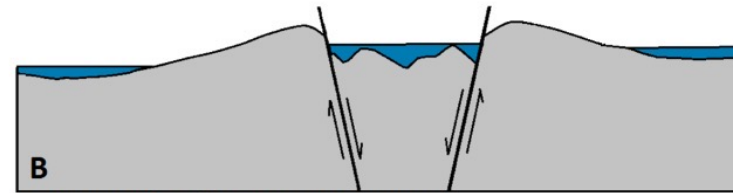
d Artinskian stage (280Ma - 290 Ma)



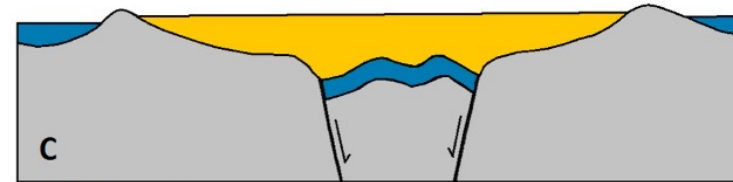
e Rodian stage (269 Ma - 272 Ma)



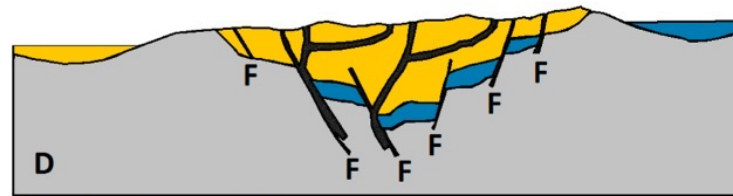
A. Deposition of glaciogenic lower Gondwana formations on uneven basement



B. Narrow rift valley formation during Early Permian



C. Lateral expansion of the rift valleys



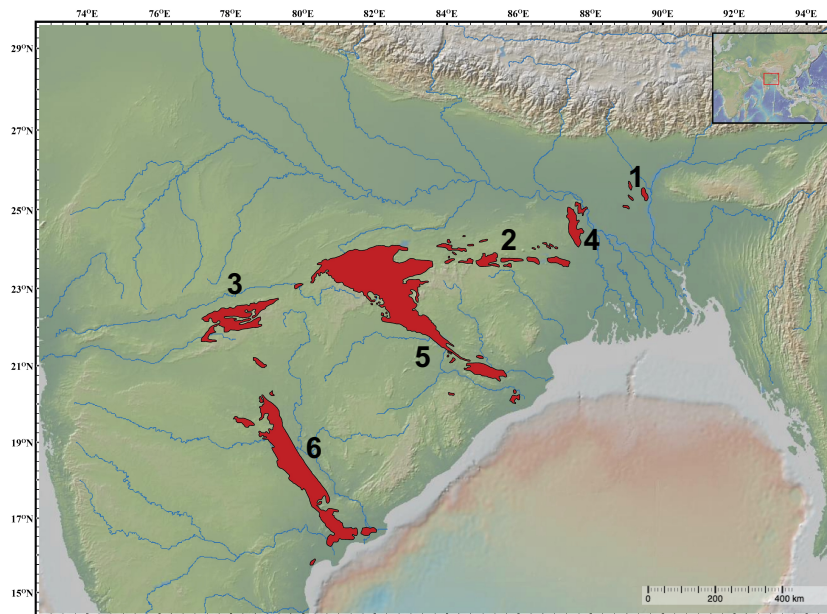
D. Post Gondwanan rifting





# Stratigraphic formations between basins in the Indian Platform

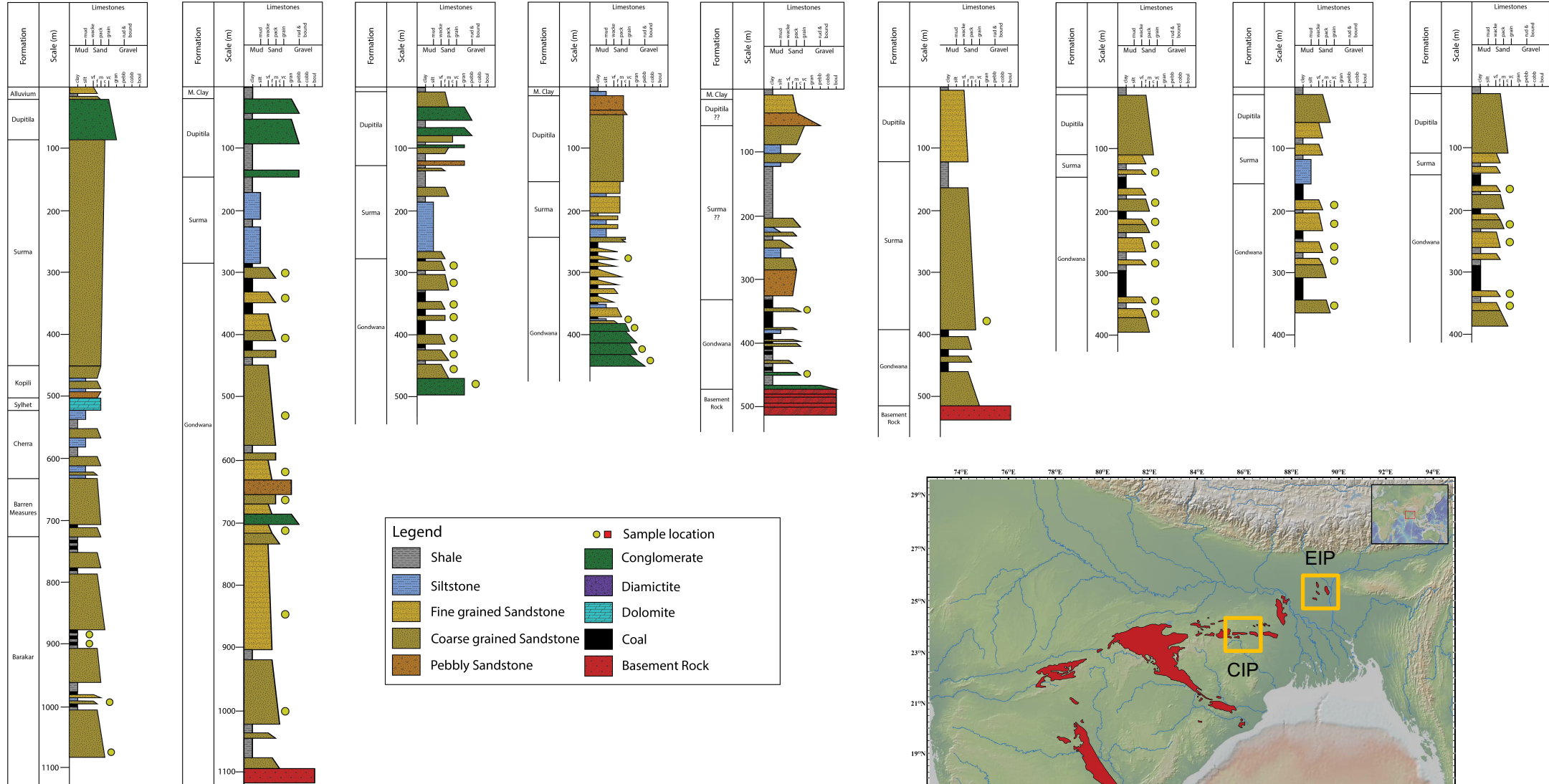
Age		1 Northwestern Bangladesh	2 Koel-Damodar	3 Satpura	4 Rajmahal	5 Son-Mahanadi	6 Pranhita-Godavari
Permian	Upper	Paharpur	Raniganj	Bijuri		Raniganj	Lower Kamthi
			Barren Measures	Motur		Barren Measures	Barren Measures
	Lower	Kuchma	Barakar	Barakar	Barakar	Barakar	Barakar
			Karharbari				
Carboniferous	Upper						
Precambrian Crystalline Basement							



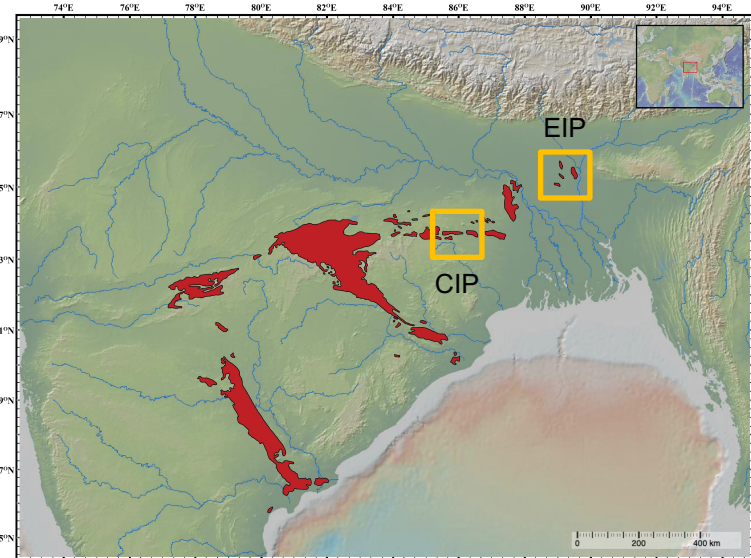
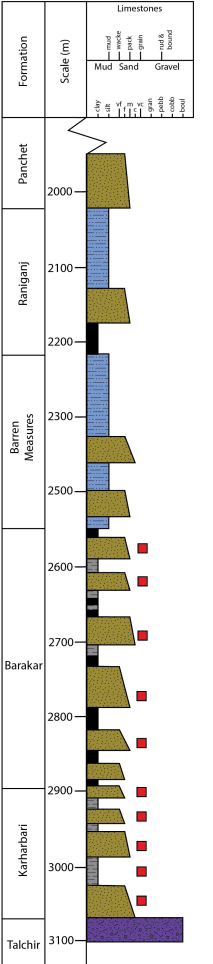


# Lithology and sample locations from basins of interest

## Eastern Indian Platform

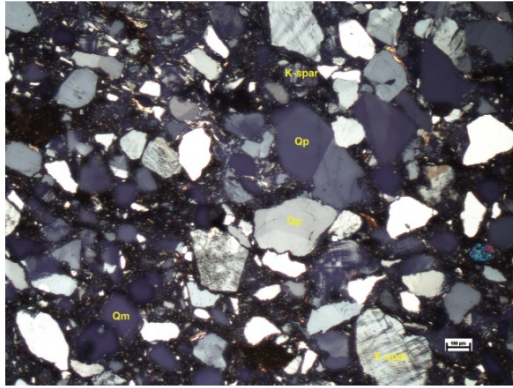


## Central Indian Platform

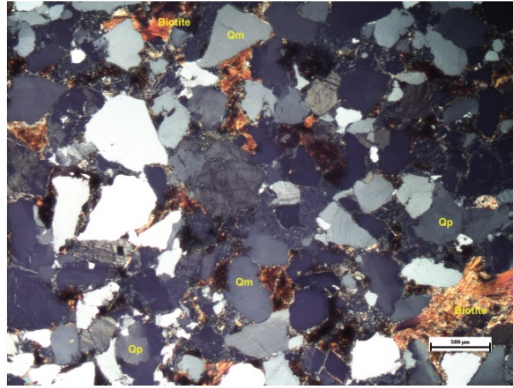




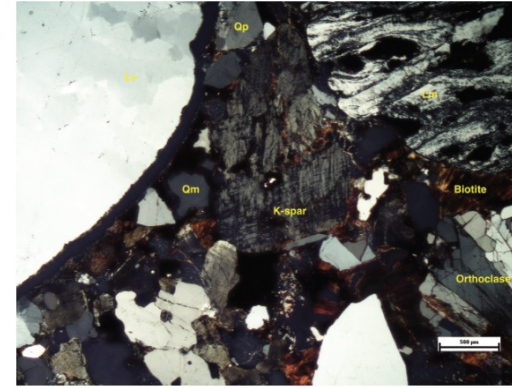
Jamalganj Basin-Sandstone



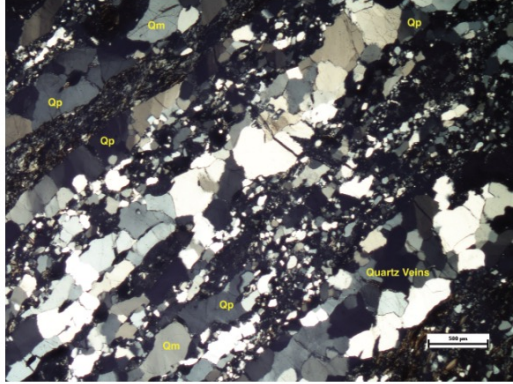
Khalashpir Basin-Sandstone



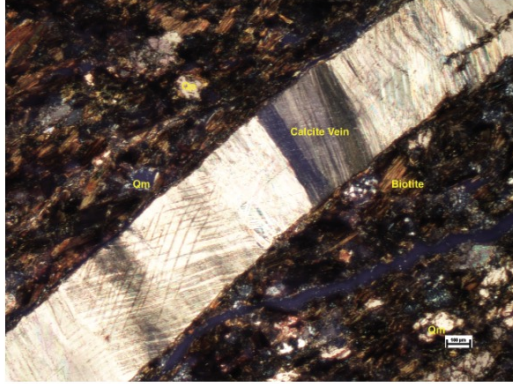
Khalashpir Basin-Conglomerate



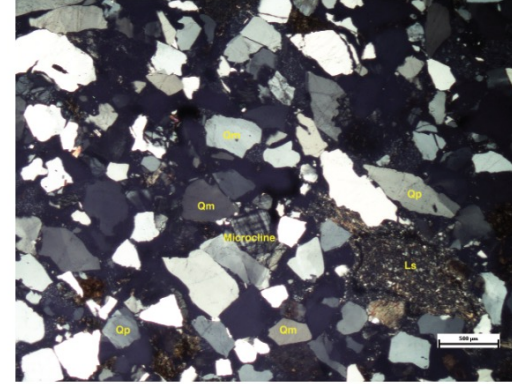
Dighipara Basin-Sandstone



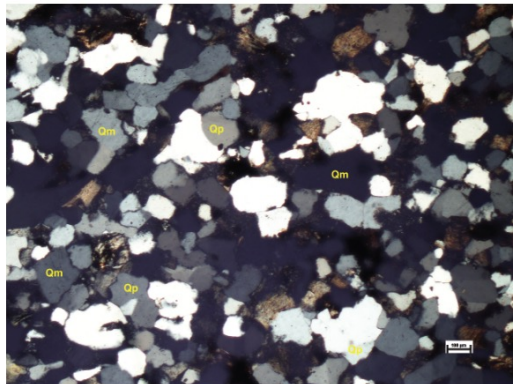
Dighipara Basin-Sandstone



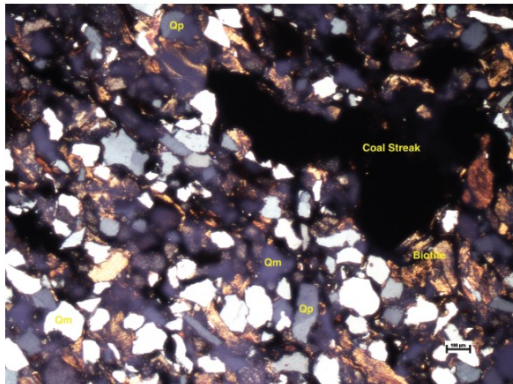
Barapukuria Basin-Sandstone



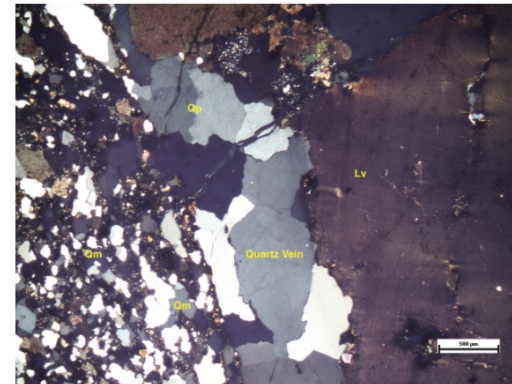
Barakar Fm., Jharia Basin-Sandstone



Barakar Fm., Jharia Basin-Sandstone

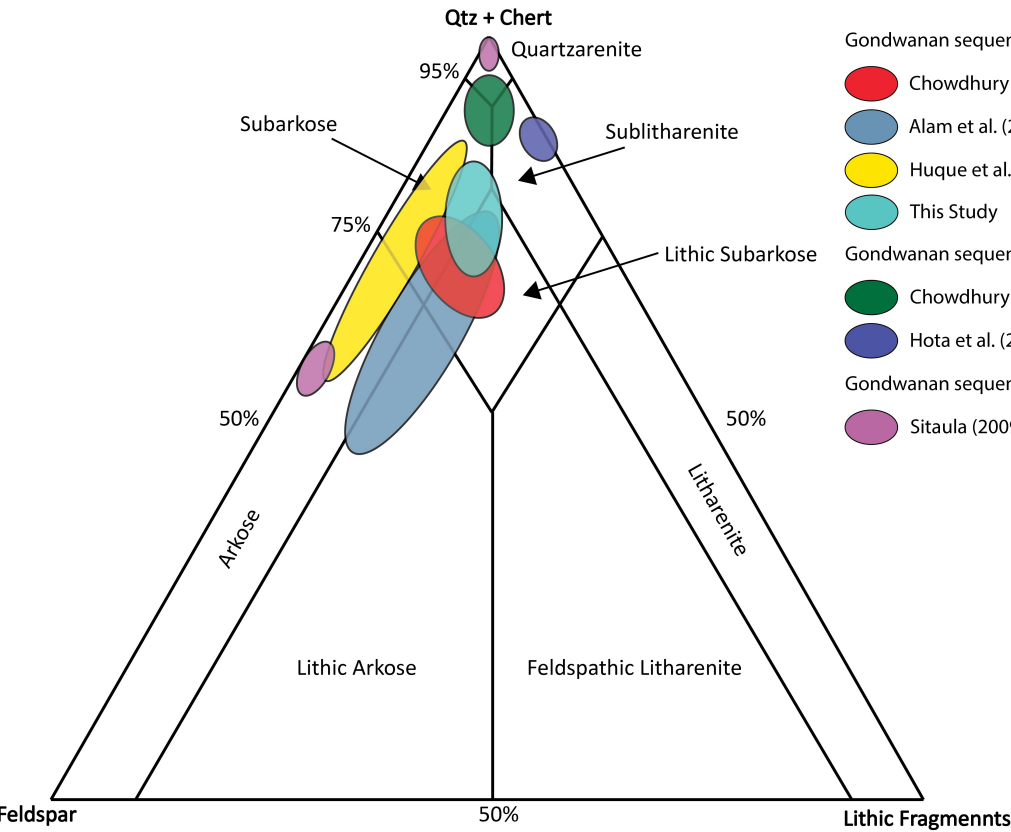


Talchir Fm., Jharia Basin-Conglomerate

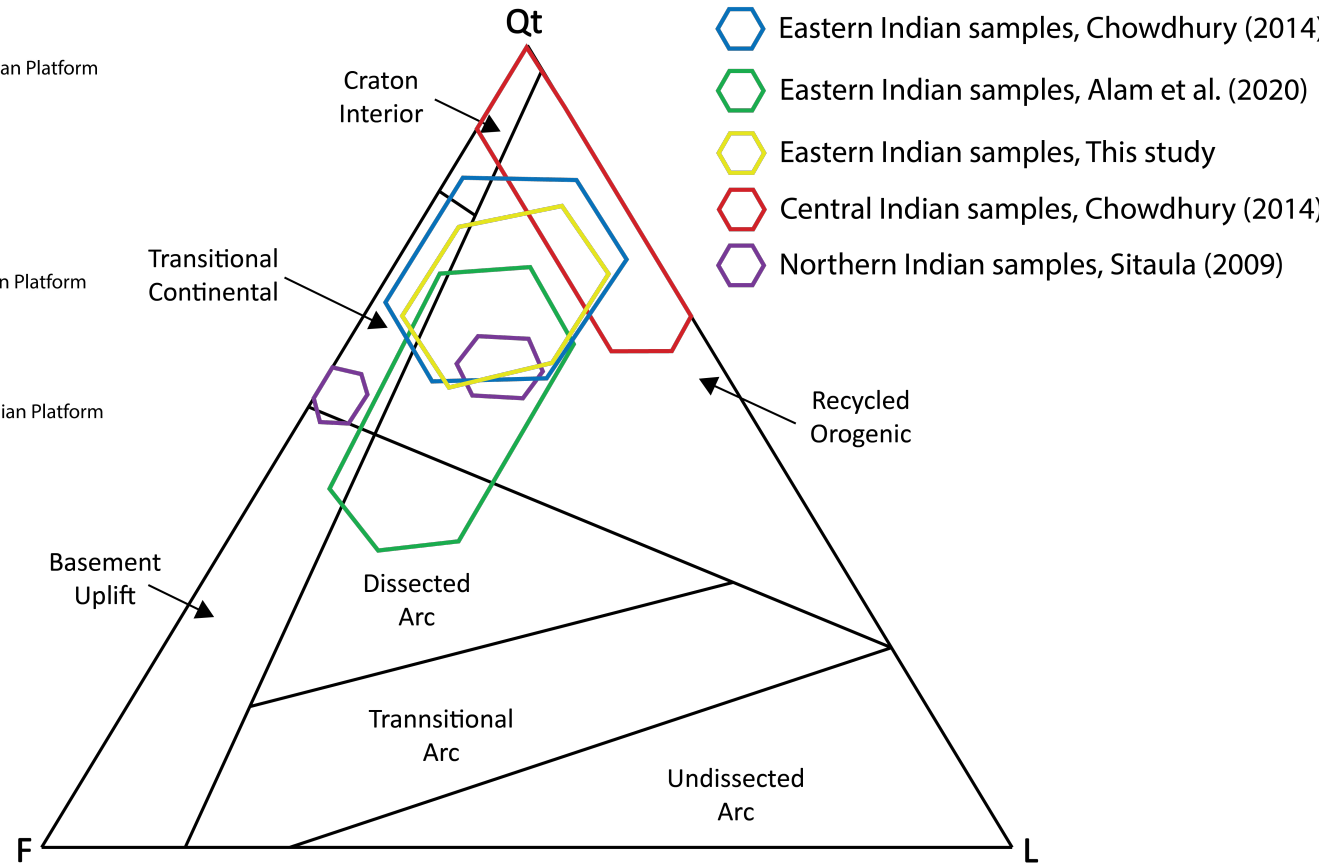


**Eastern Indian Platform**

**Central Indian Platform**



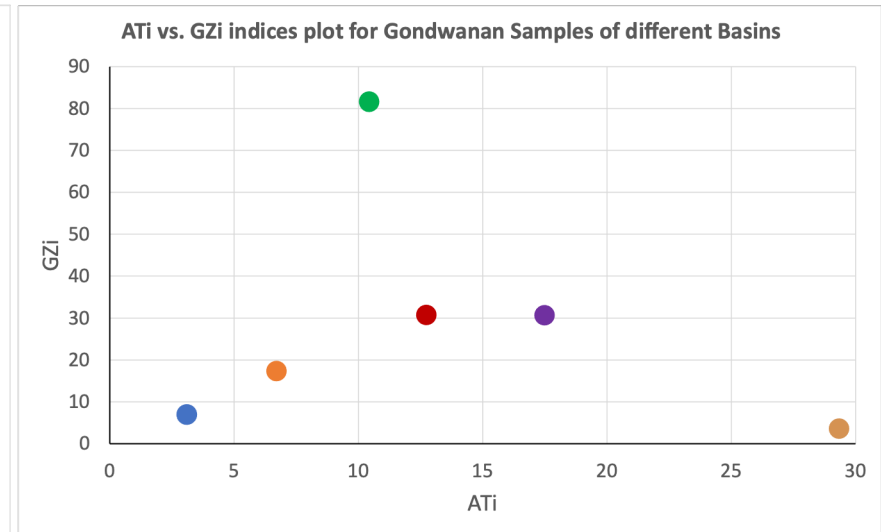
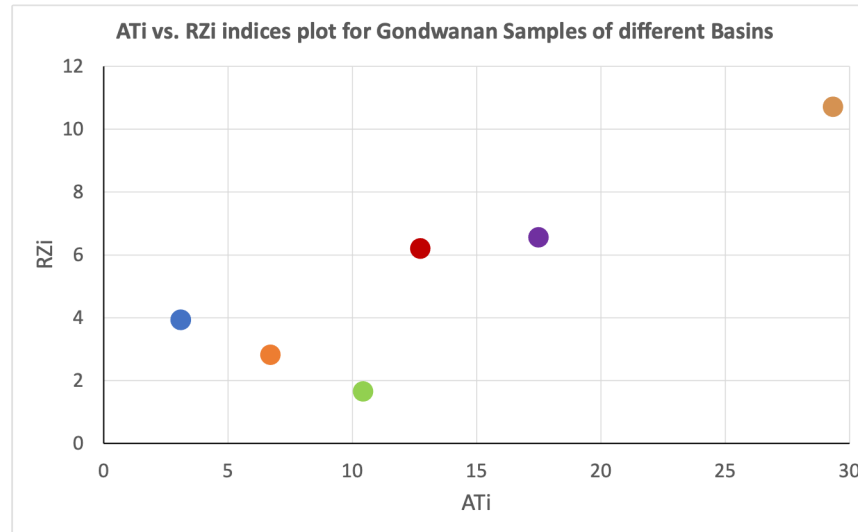
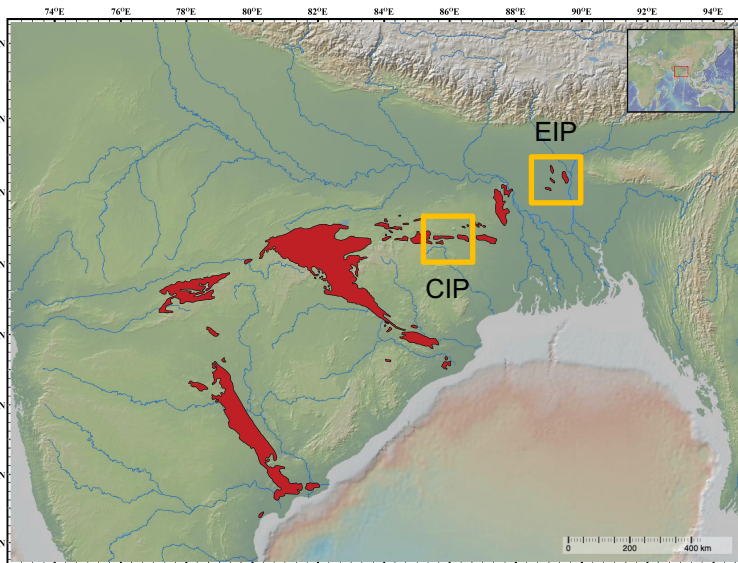
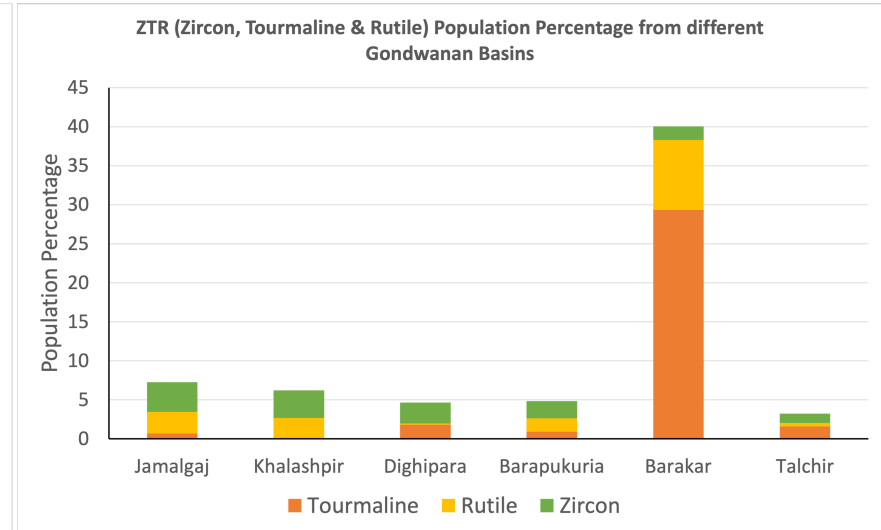
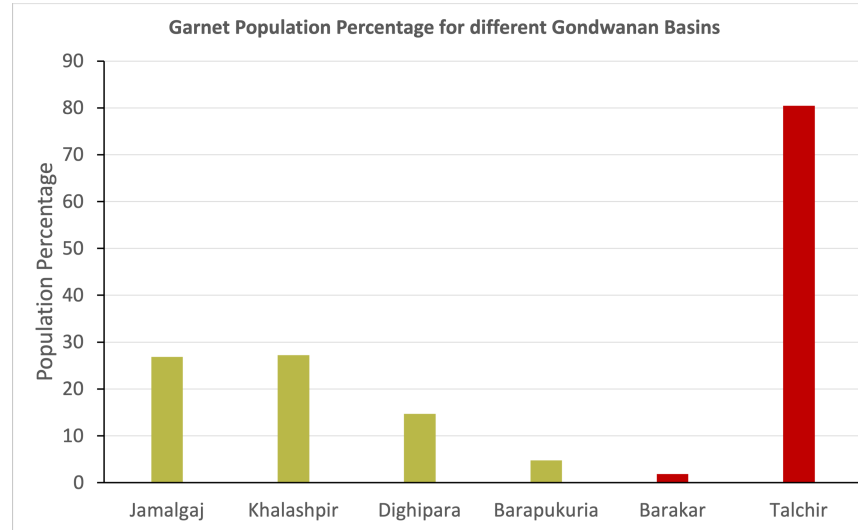
Sandstone composition fields adapted from McBride, 1963



Tectonic fields adapted from Dickinson, 1985

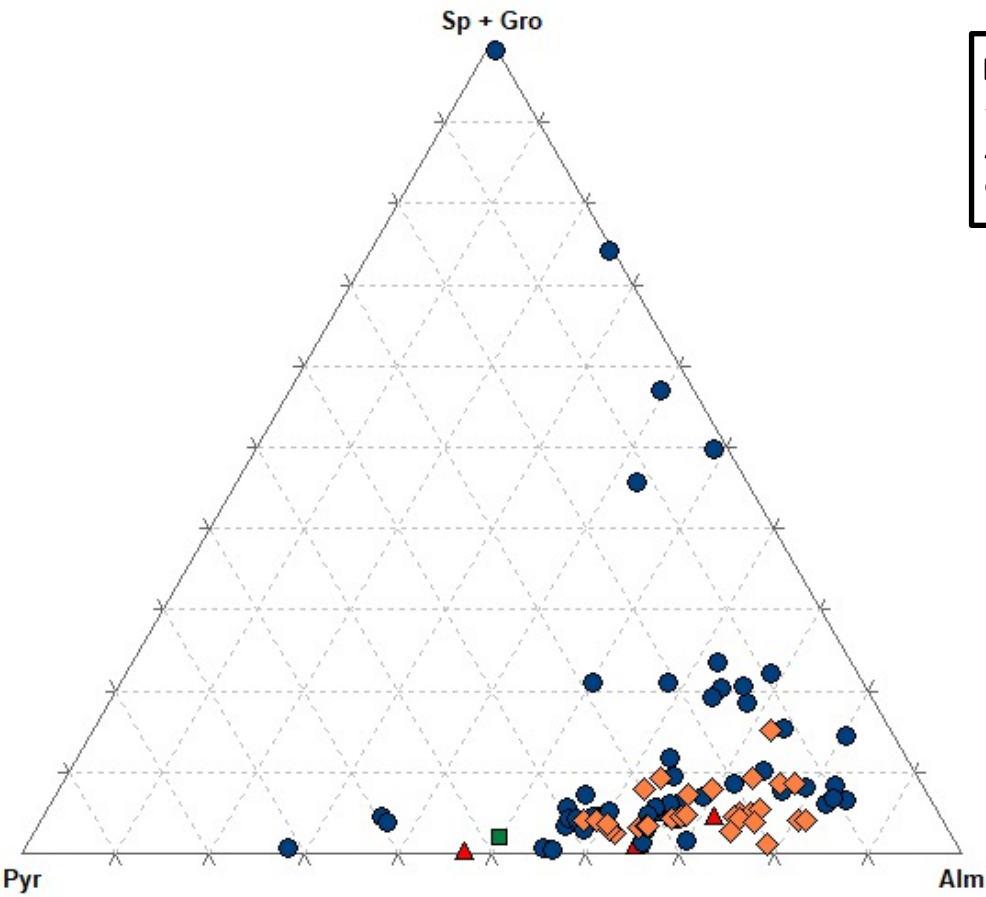


- Upper Gondwanan sediments:
  - High population of ZTR
  - Low population of Garnet
- Lower Gondwanan sediments:
  - Low population of ZTR
  - High population of Garnet

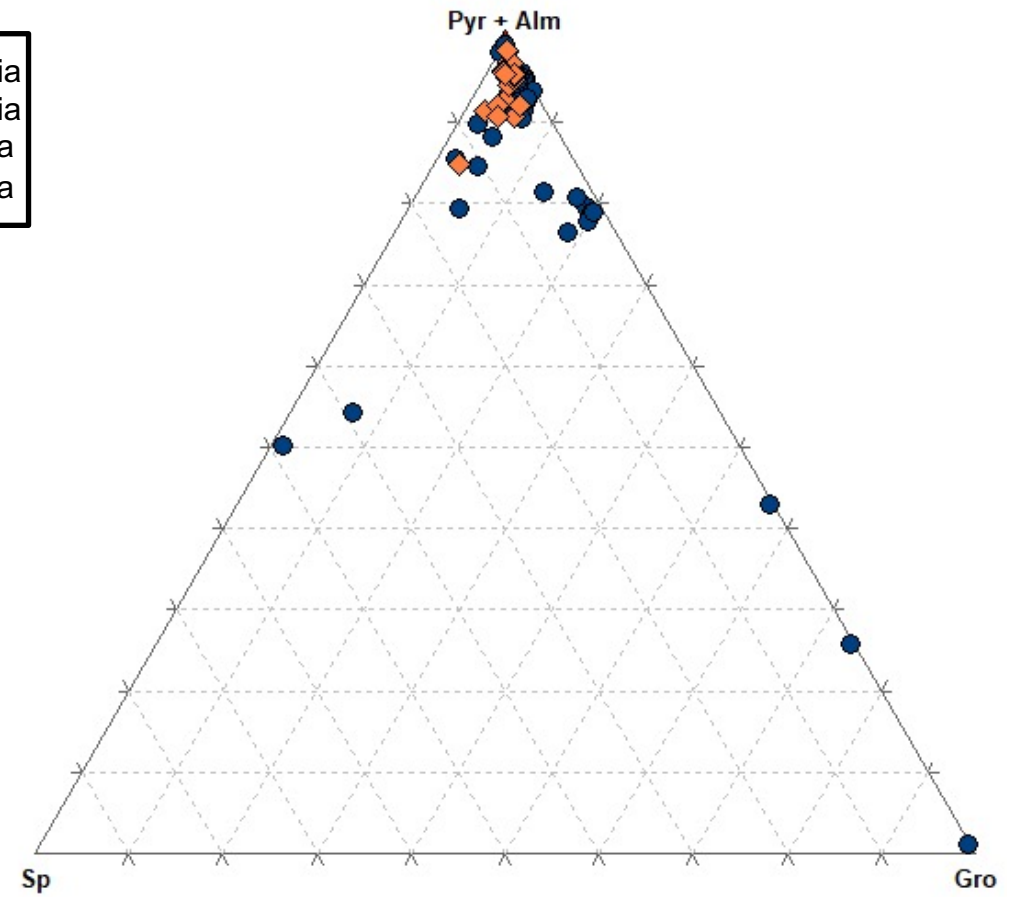


- Jamalgaaj
- Khalashpir
- Dighipara
- Barapukuria
- Barakar Fm., Jharia
- Talchir Fm., Jharia



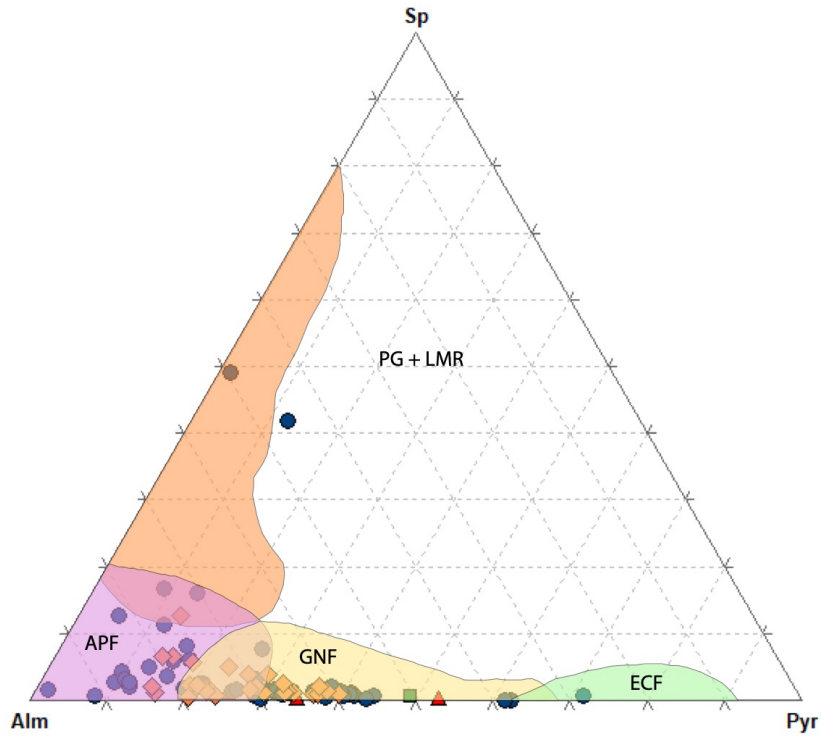


- Upper Gondwana – Eastern India
- ◆ Lower Gondwana – Eastern India
- ▲ Upper Gondwana – Central India
- Lower Gondwana – Central India

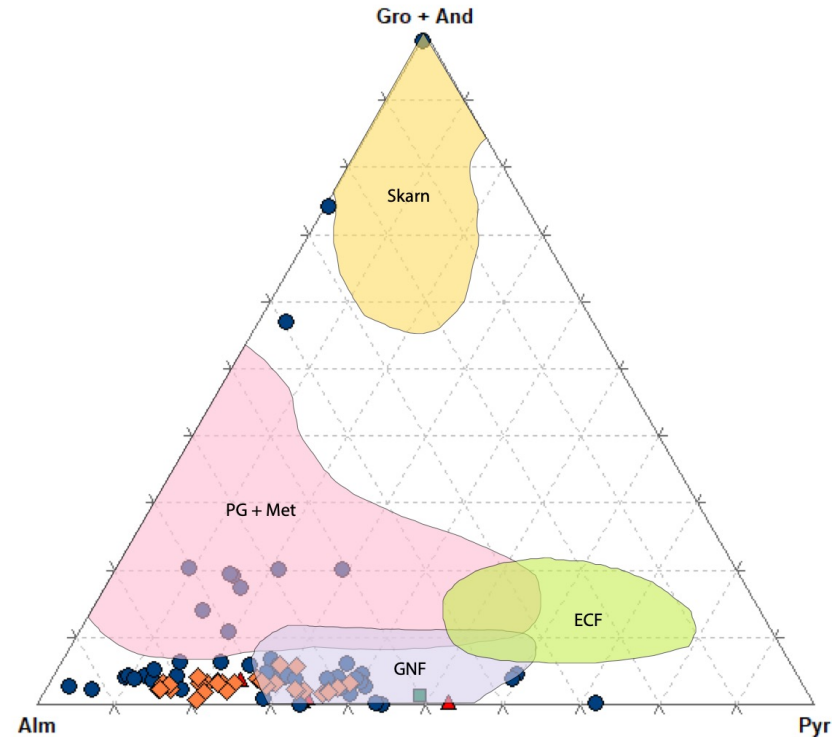


Mg	Na	Al <sub>3</sub>	Si <sub>6</sub>	Ca <sub>2</sub>	Ti <sub>2</sub>	Fe <sub>2</sub>	Mn
OI 2566	Amelia	Anorthite	Wollastonite	Wollastonite	Ilmenite	Fayalite	P-130

Garnet chemical compositional ternary plots after Nanayama (1997)

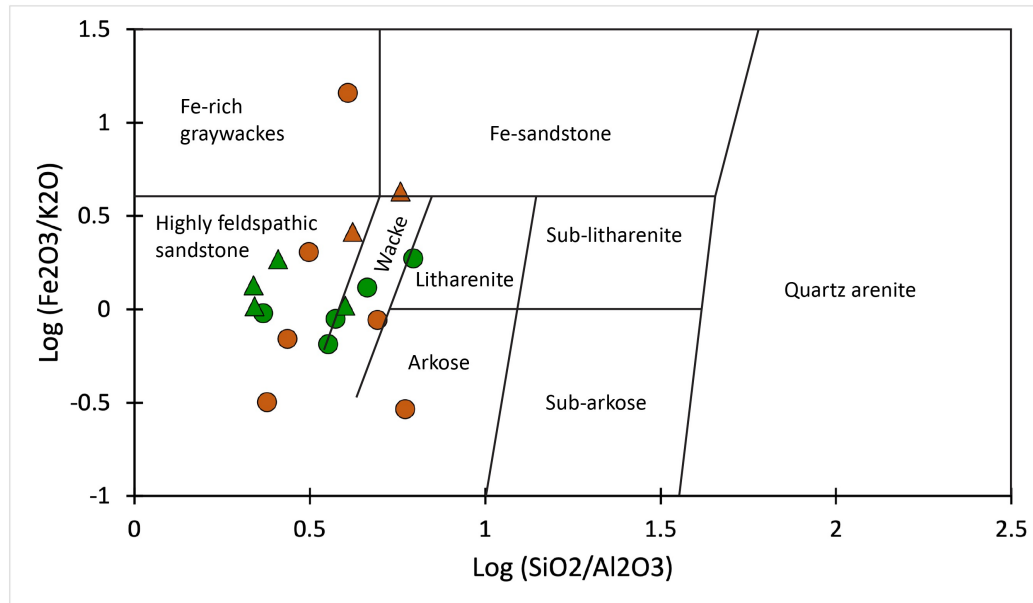


Legend	
▲	Barakar Fm. - India
●	Talchir Fm. - India
■	Upper Gondwana - Bangladesh
◆	Lower Gondwana - Bangladesh
Sp - Spessartine	
Pyr - Pyrope	
Alm - Almandine	
APF - Amphibolite facies	
GNF - Granulite facies	
ECF - Eclogite facies	
PG - Pegmatites	
LMR - Low metamorphic rock	



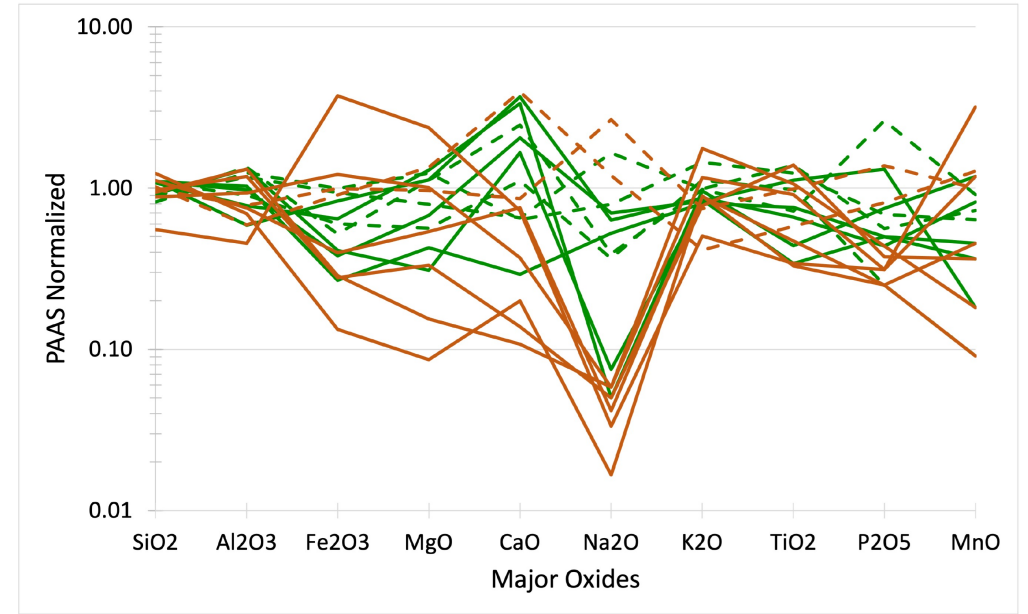
Legend	
▲	Barakar Fm. - India
●	Talchir Fm. - India
■	Upper Gondwana - Bangladesh
◆	Lower Gondwana - Bangladesh
Gro - Grossular	
And - Andradite	
Pyr - Pyrope	
Alm - Almandine	
GNF - Granulite facies	
ECF - Eclogite facies	
PG - Pegmatites	
Met - Metamorphic rock	

- Majority of the sandstones fall between **highly feldspathic** and **wacke to litharenite and arkose**.
- Major oxide data indicate a **deficiency of Na<sub>2</sub>O** while **increase in K<sub>2</sub>O** indicating the feldspars are K-spars type
- REE patterns indicates a similar trend
  - Lower Gondwanan sediments have a **higher concentration** compared to Upper Gondwanan sediments

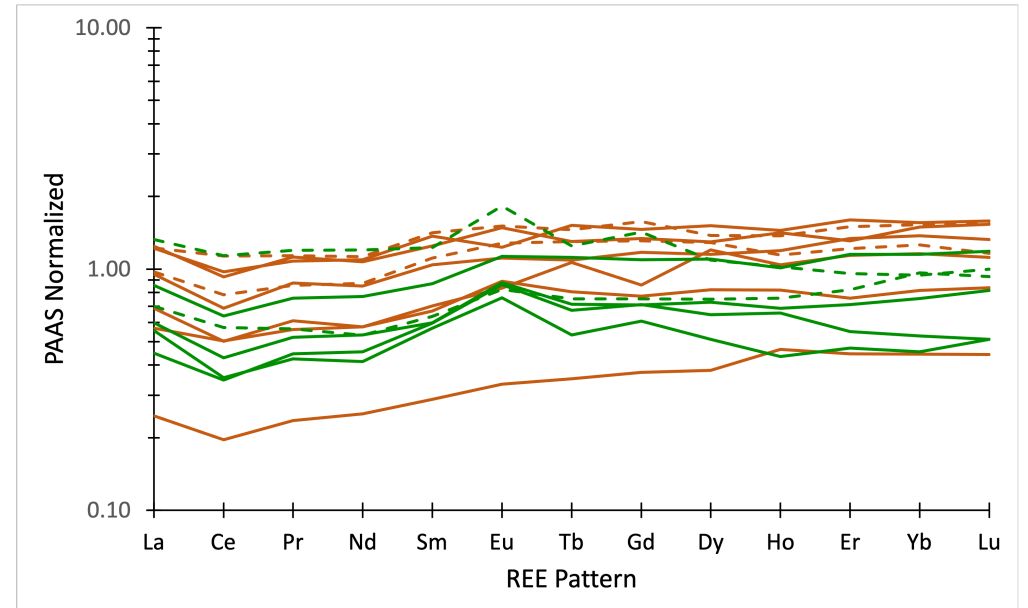


● Upper Gondwana - Central India     ● Upper Gondwana - Eastern India  
▲ Lower Gondwana - Central India     ▲ Lower Gondwana - Eastern India

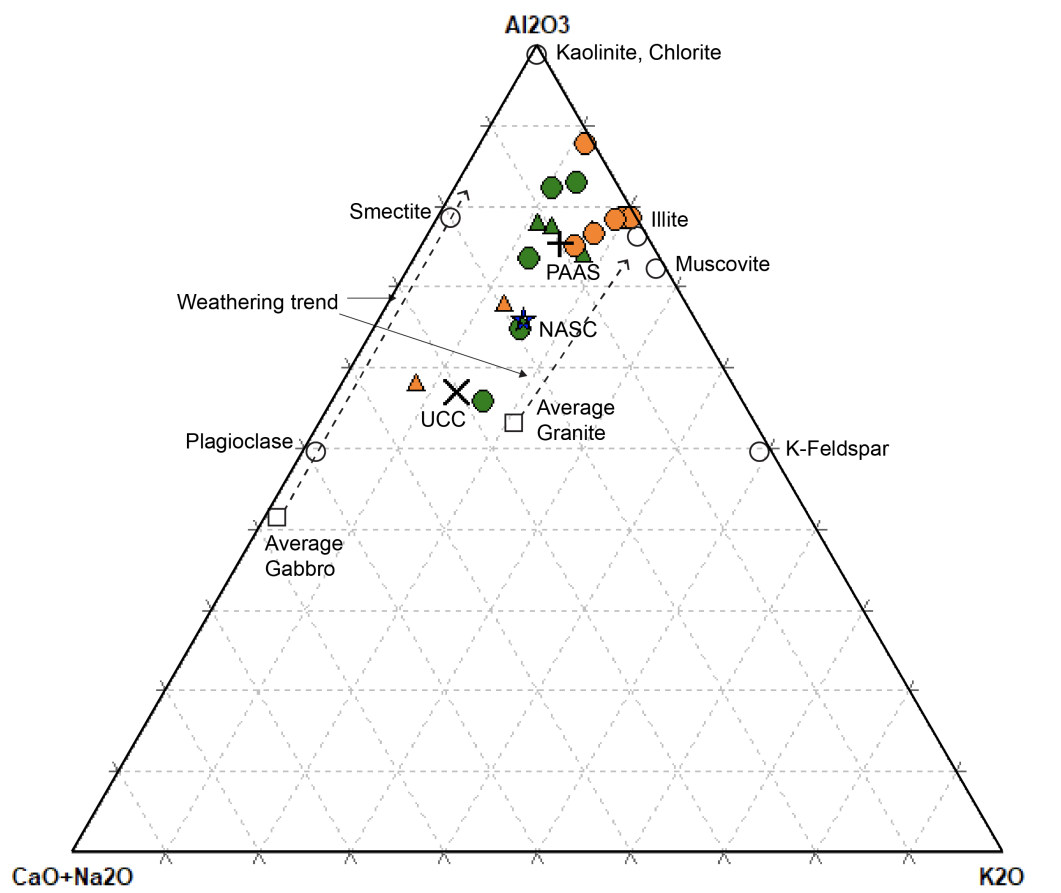
Sandstone composition fields adapted after Herron (1988), Central Indian data from Chowdhury (2014)



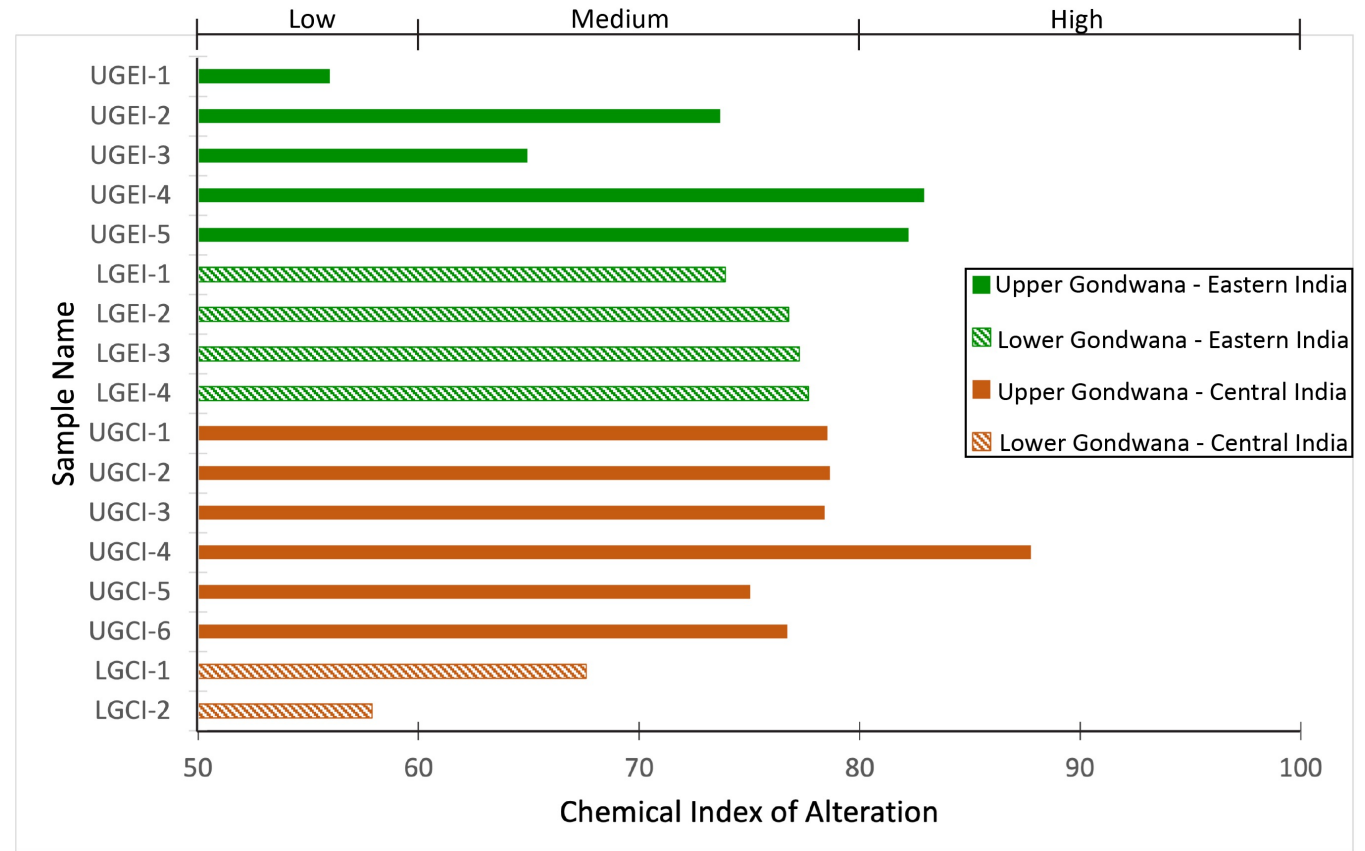
— Upper Gondwana - Central India     — Upper Gondwana - Eastern India  
- - - Lower Gondwana - Central India     - - - Lower Gondwana - Eastern India







- Upper Gondwana - Central India
- ▲ Lower Gondwana - Central India
- PAAS - Post Archean Australian Shale
- NASC - North American Shale Composite
- Upper Gondwana - Eastern India
- ▲ Lower Gondwana - Eastern India
- UCC - Upper Continental Crust

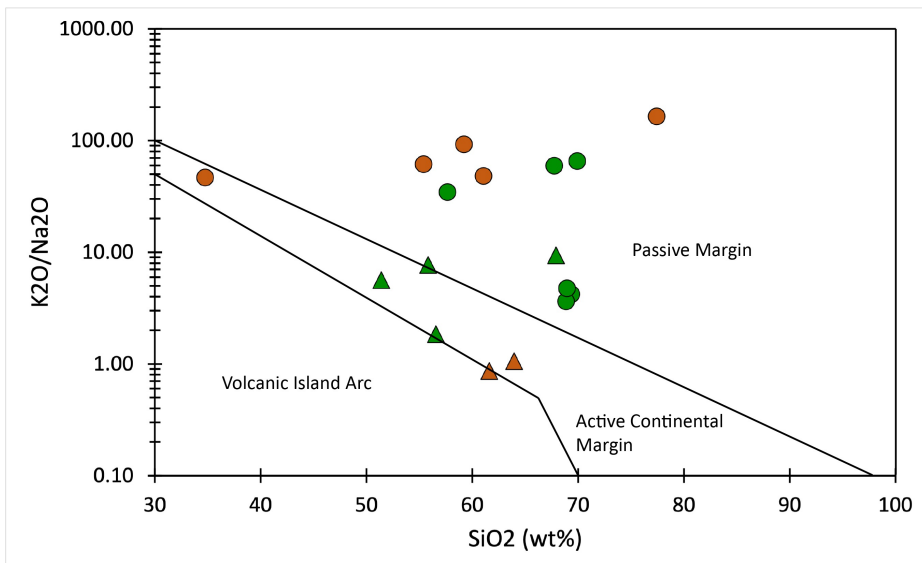
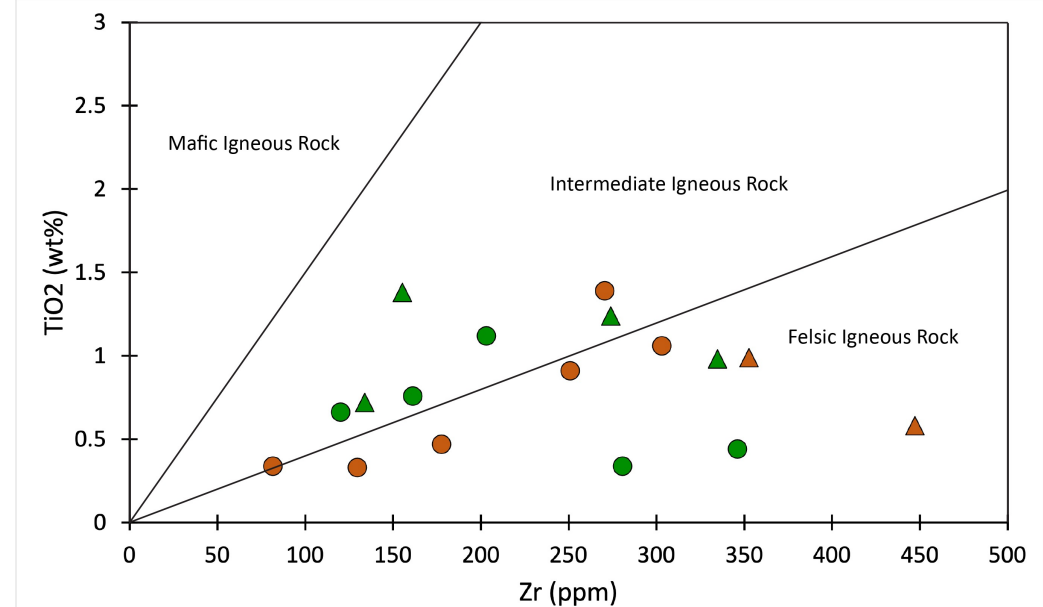
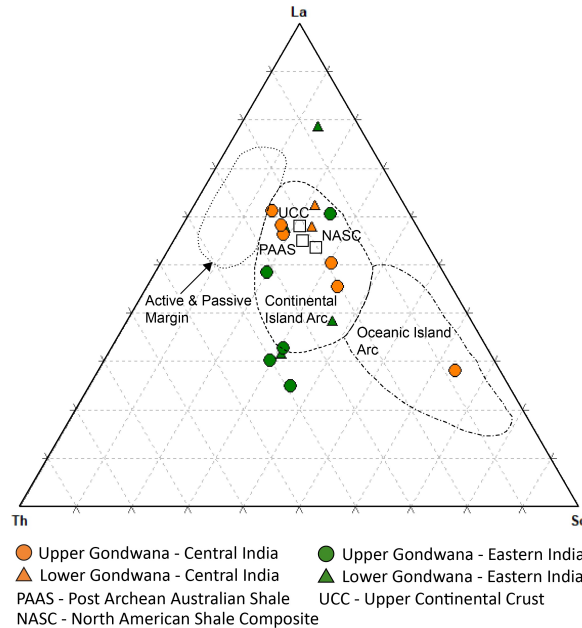


**Chemical Index of Alteration (CIA) =  $[(Al_2O_3) / (Al_2O_3 + CaO + Na_2O + K_2O)] \times 100$**

A-CN-K plot adopted after Nesbitt and Young (1989); PAAS, UCC and NASC data based on Taylor and McLennan (1985); Central Indian data from Chowdhury (2014)

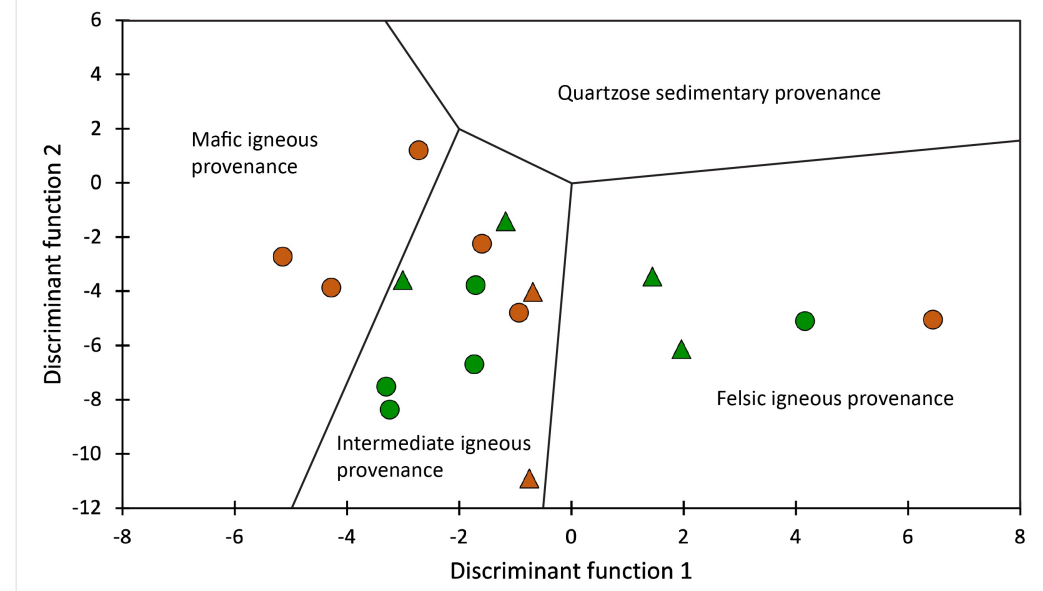
Adopted after Nesbitt and Young (1982) and Soreghan and Soreghan (2007); Central Indian data from Chowdhury (2014)

- La-Th-Sc ternary plot indicate majority of samples have **affinity to continental island arc tectonic setting**.
- $(K_2O/Na_2O)$  vs  $SiO_2$  plot suggest **lower Gondwanan** sediments have affinity to **active continental margin** whereas **upper Gondwanan** sediments are from **passive margin** setting.
- $TiO_2$  vs Zr plot indicate **mixing from both felsic and intermediate igneous** terranes.
- Discriminant function plot indicate possible mixing from all different type of **igneous terranes**.



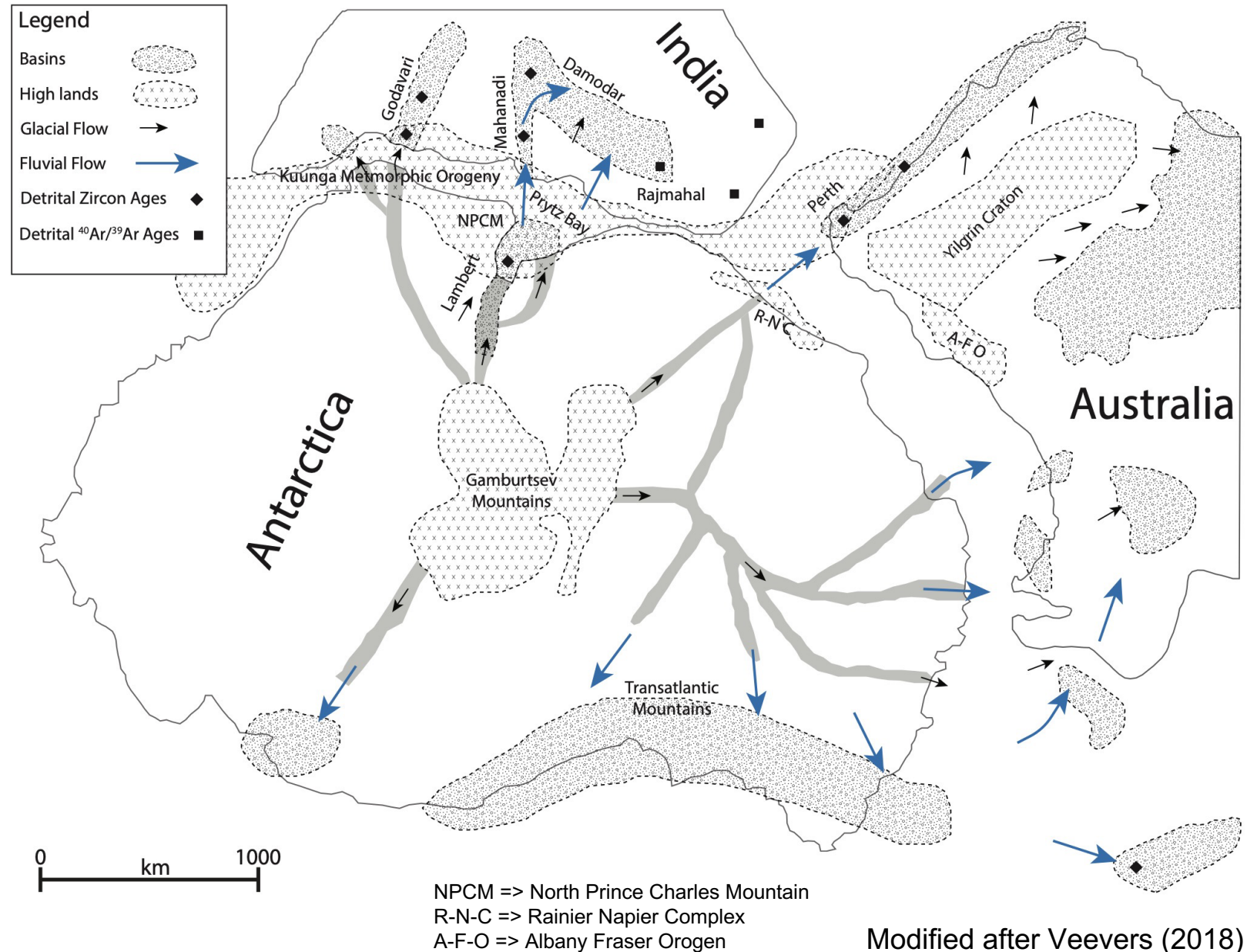
- **Discriminant Function 1 =  $(-1.773 \times TiO_2) + (0.607 \times Al_2O_3) + (0.760 \times Fe_2O_3) + (-1.500 \times MgO) + (0.616 \times CaO) + (0.509 \times Na_2O) + (-1.224 \times K_2O) + (-9.090)$**
- **Discriminant Function 2 =  $(0.445 \times TiO_2) + (0.070 \times Al_2O_3) + (-0.250 \times Fe_2O_3) + (-1.142 \times MgO) + (0.438 \times CaO) + (1.475 \times Na_2O) + (-1.426 \times K_2O) + (-6.861)$**

- La-Th-Sc plot fields adopted after Bhatia and Crook (1986)
- $(K_2O/Na_2O)$  vs  $SiO_2$  plot fields adopted after Roser and Korsch (1986)
- $TiO_2$  vs Zr plot fields adopted after Hayashi et al. (1997)
- Discriminant function plot fields adopted after Roser and Korsch (1988)



- Upper Gondwana - Central India    ● Upper Gondwana - Eastern India
- ▲ Lower Gondwana - Central India    ▲ Lower Gondwana - Eastern India

- Gondwanan basins in Indian platform **didn't form as a major basin** contradicting Veevers (1995, 2018)
- Petrological analyses indicate **lower Gondwanan** sediments are **less mature** compared to **upper Gondwanan sediments**.
- Heavy mineral population indicate **possible change of source** terrane between upper and lower Gondwanan sediments.
- Garnet composition and population support heavy mineral analyses.
- Both **upper and lower Gondwanan** samples have been moderately weathered.
- Whole rock data indicate **mixing** from **felsic and intermediate** igneous source terrane with some influence from **mafic** igneous rocks.



Modified after Veevers (2018)



- Gondwana sediments show **variation in composition** between Carboniferous (lower Gondwana) and Permian (upper Gondwana) sediments.
- Petrographic analysis indicate majority of the samples came from **Recycled Orogenic** setting.
- Heavy mineral data indicate **variation between lower and upper Gondwanan** sediments.
- Compositional analyses of Garnet grains show possible **mixture of Amphibolite and Granulite facies** of metamorphic terranes in the upper Gondwanan sediments.
- Whole-rock geochemistry indicate **lower Gondwanan sediments to have active margin affinity** whereas **upper Gondwanan sediments shows affinity to passive margin setting**.
- Possible changes in the source terrane can be related to **climatic variation** throughout the depositional period and **sediment transportation network**.

- Thanks to the following organizations for grants to support this research:
  - AAPG Grants-in-aid program
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  - Geosciences Advisory Board, Dept. of Geosciences, Auburn University
  
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**Thank You**  
**Questions?**