

# **Early Permian Siliciclastic System of North-Gondwanaland: A Comparison between Nilawahan Group of North Pakistan and Haushi Group of Oman\***

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## **Abstract**

The early Permian siliciclastic system of north Gondwanaland is represented by the rocks of the Haushi Group in the Oman Interior Basin and the Nilawahan Group in the Salt Ranges of the northern Pakistan. The rocks of the two time-equivalent groups, though exposed ~2500 kilometers apart, share great similarities in their lithofacies association, composition and depositional systems. The upper Paleozoic sediments of the Haushi Group host major hydrocarbon reservoirs in the Oman Interior Basin. This clastic sequence represents 3rd episode of Gondwanan glaciation in the Arabian Peninsula and is composed of glacial and glacio-fluvial deposits of the Al-Khlata Formation, overlain by the fluvial dominated Gharif Formation. This clastic sequence is widely distributed in the subsurface of the Oman Interior Basin and surrounding parts of the Arabian Peninsula such as in Saudi Arabia and U.A.E. The siliciclastic rocks of the late Paleozoic Nilawahan Group in the Salt Ranges in north Pakistan are comprised of the glacial and glacio-fluvial Tobra Formation, the deltaic to estuarine Dandot Formation, and overlain by the fluvial Warchha Formation and near-shore, coastal-marine Sardhai Formation. This study describes and compares the lithofacies association of the two groups to interpret the depositional system and tectonic context of the two widely-separated sedimentary sequences.

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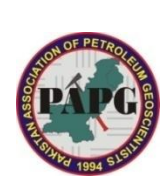
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# OBJECTIVES

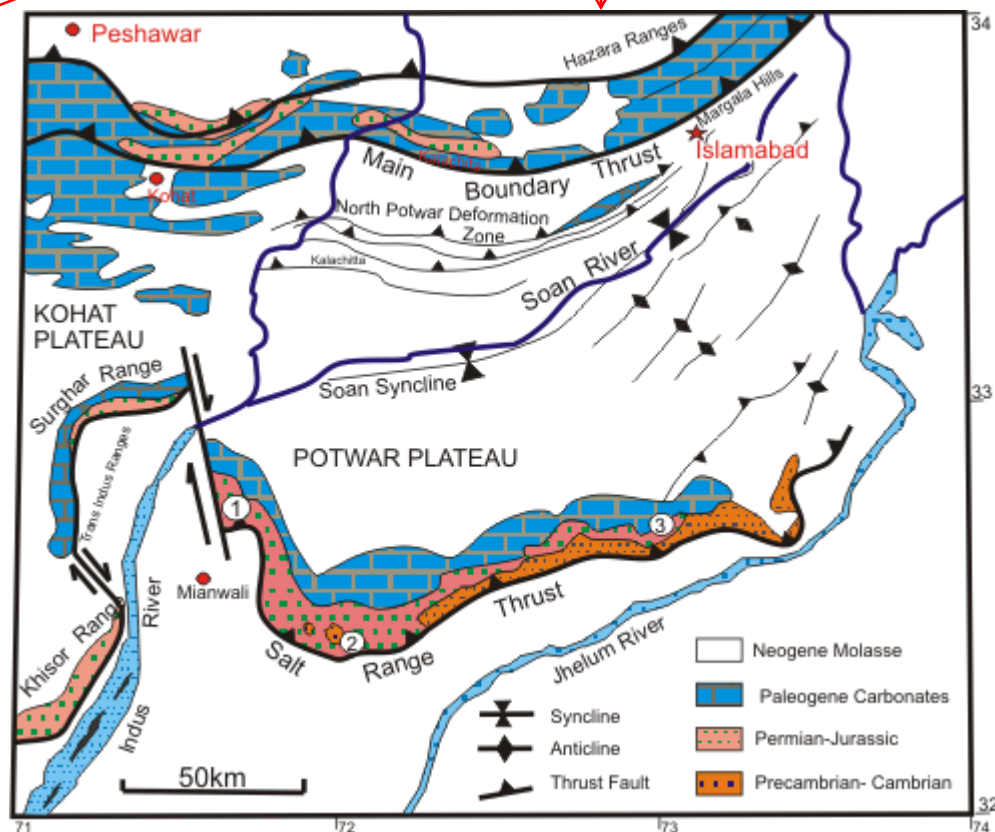
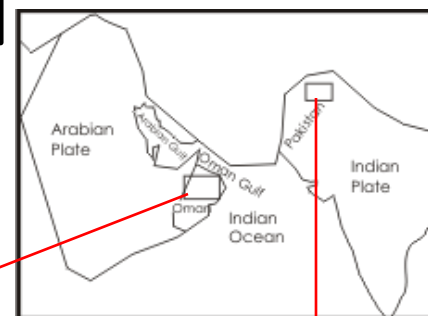
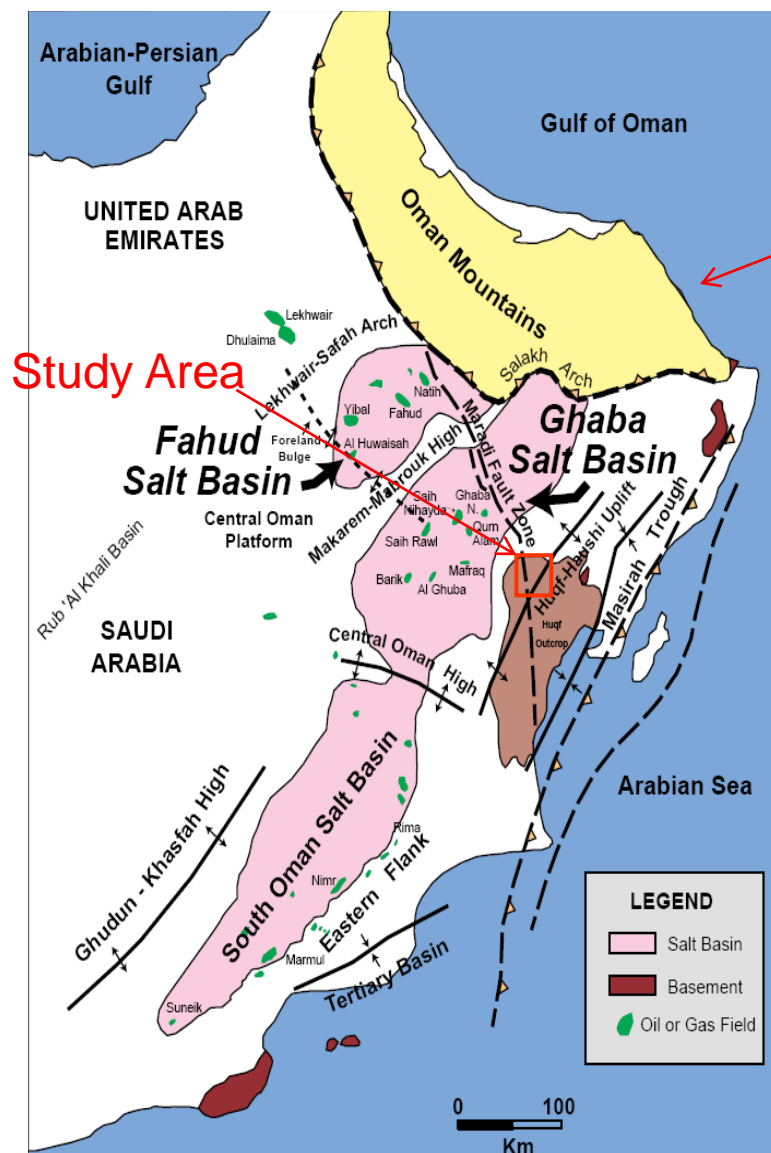
- Distribution of Nilawahan and Haushi Groups in north Pakistan and central Oman
- Stratigraphy of two groups
- Lithofacies Assemblage
- Depositional System
- Paleogeographic Setting

# INTRODUCTION

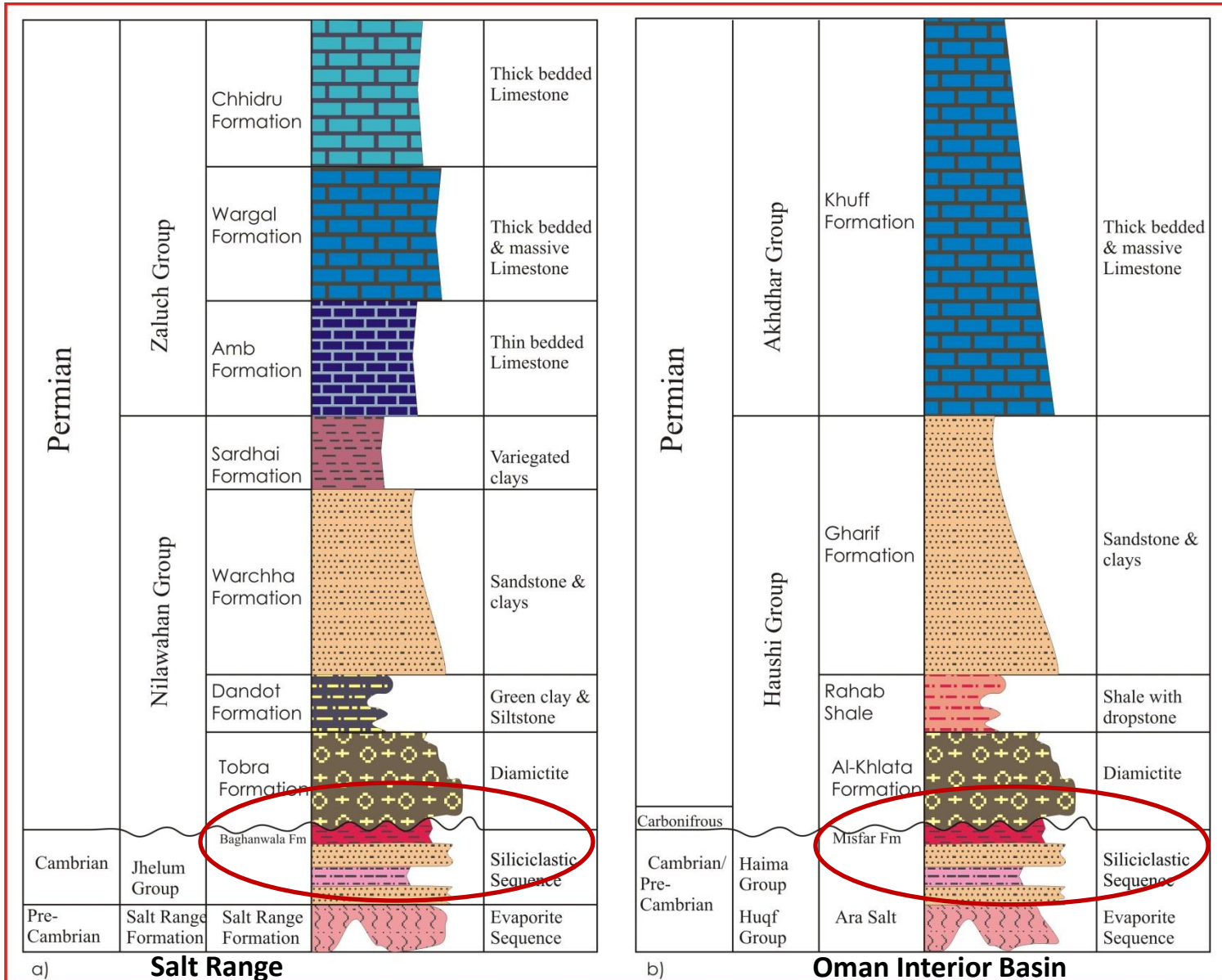
- Nilawahan & Haushi Groups are late Paleozoic siliciclastic sequences
- Glacial, glaciofluvial, fluvial and marginal marine in origin
- Unconformably overlies the early Paleozoic siliciclastic & evaporite sequences
- Haushi Group is a major hydrocarbon producing horizon in Oman and similar deposits host huge reserves throughout the Middle East (Unayzah Formation in Saudi Arabia, Kuwait). No major discovery from the Nilawahan Group in Pakistan.
- Remarkable similarities in geology of both groups though deposited in different basins
- Late Carboniferous-Early Permian in age



# INTRODUCTION



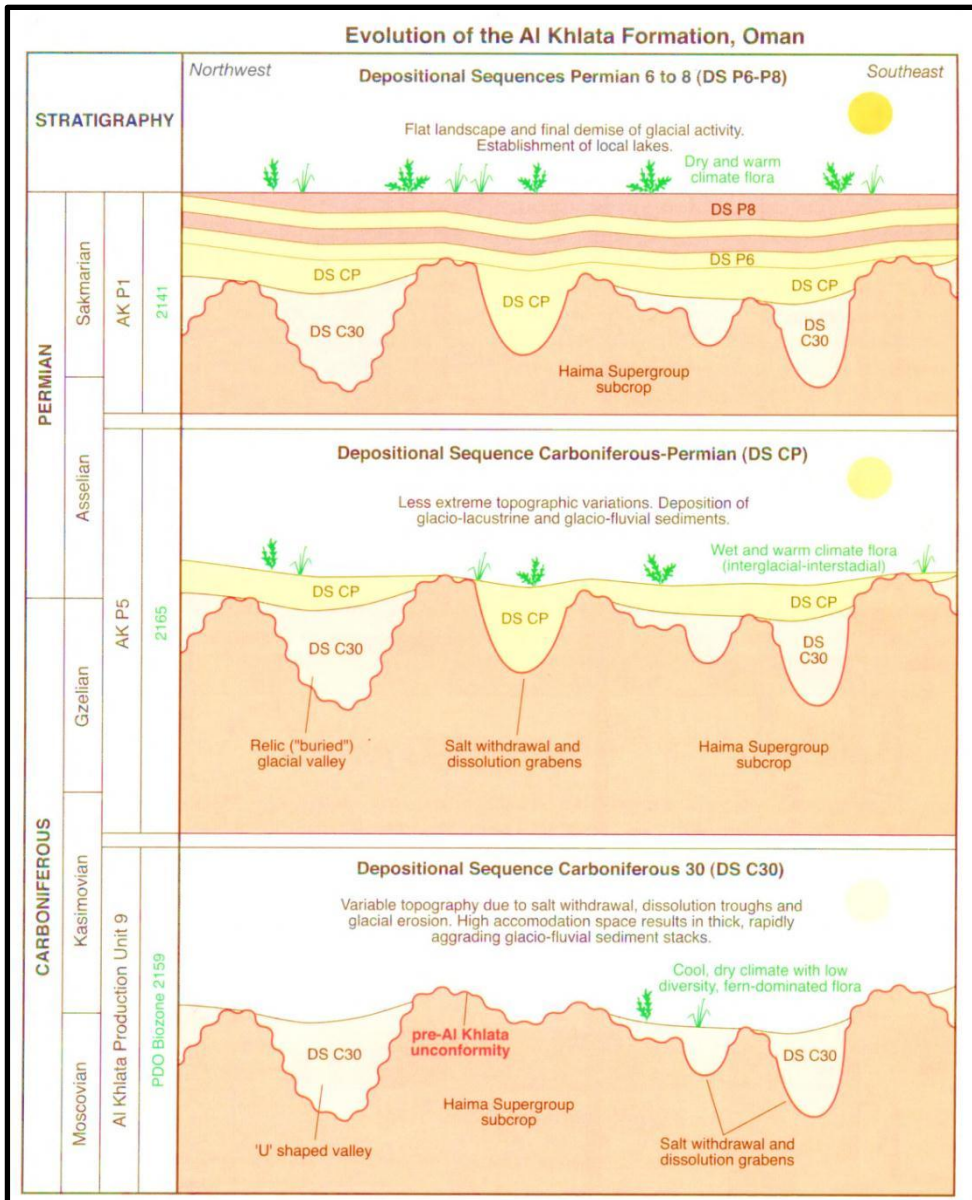
# Paleozoic Stratigraphy of Salt Ranges & Oman Central Basin



# Depositional evolution of Nilawahan & Haushi Groups

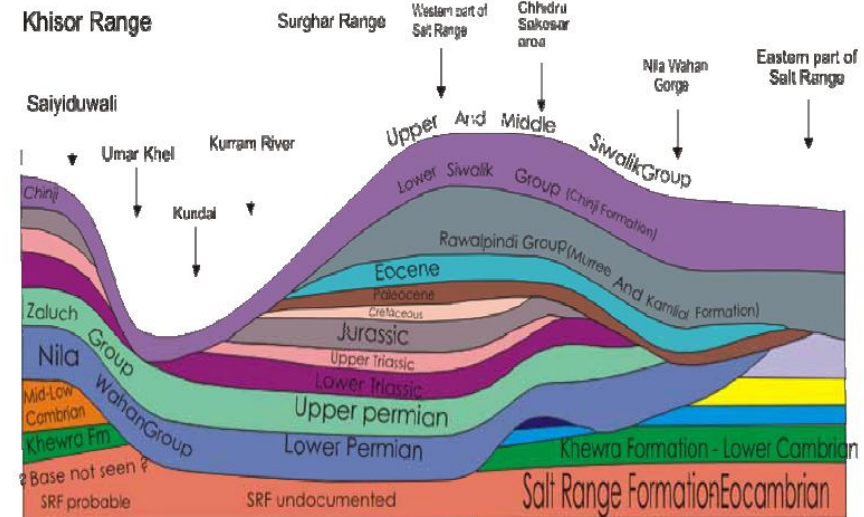
After Osterloff et al. 2004

## Evolution of the Al Khlata Formation, Oman



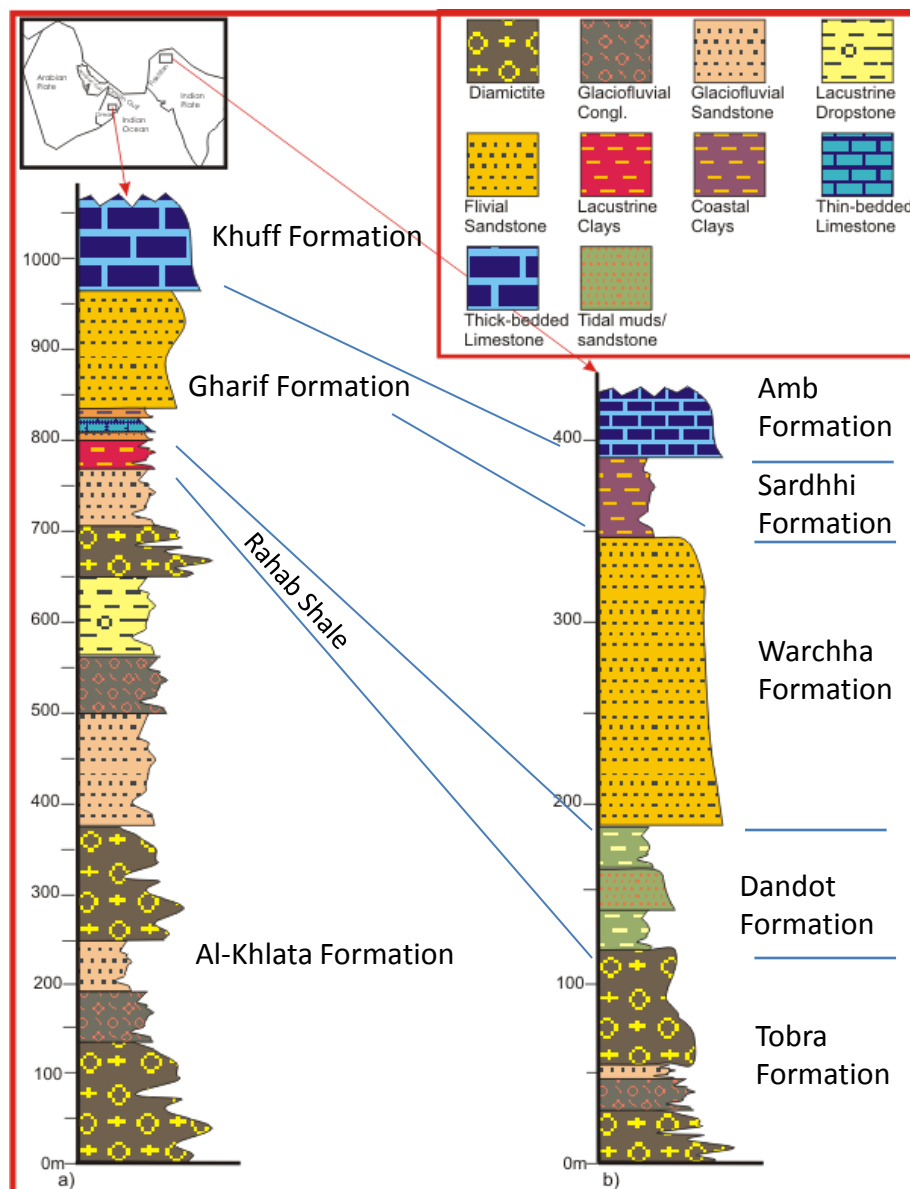
After Gee, 1945

## SALT RANGE

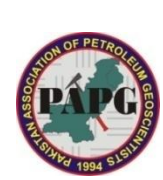


The basal glaciogenic sediments in both groups directly overlie the widespread "Hercynian Unconformity". The Infra-Cambrian salt moved diapirically, depositing Al-Khlata & Tobra sediments in synclines formed by salt withdrawal or dissolution.

# Lithostratigraphic correlation of various units



a) Oman Interior Basin,  
b) Salt Range area

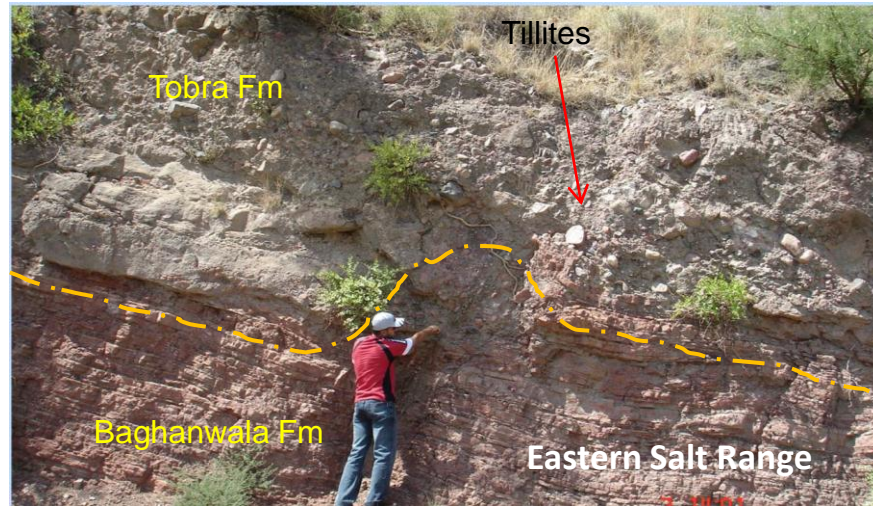


# Lithofacies Association of Tobra & Al-Khlata Formations

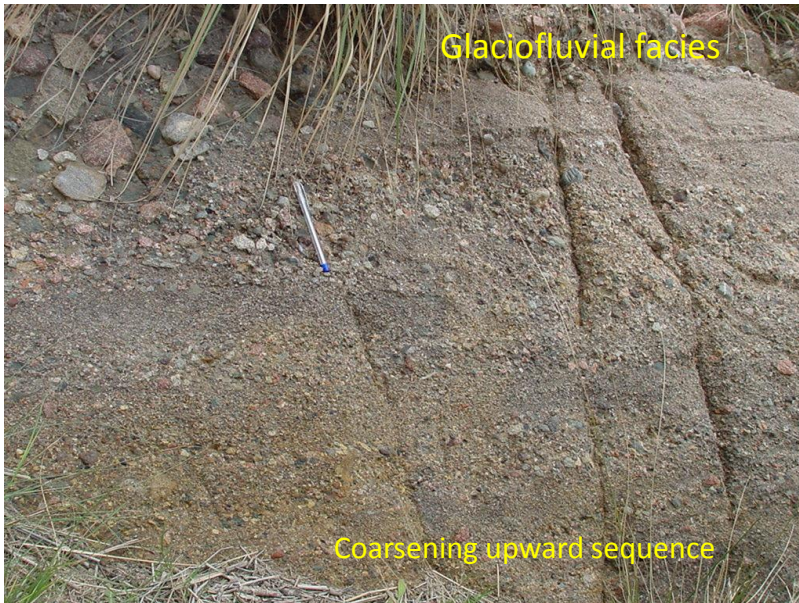


- 
- Diamictite
  - Glaciofluvial
  - Glaciolacustrine
  - Glaciodeltaic

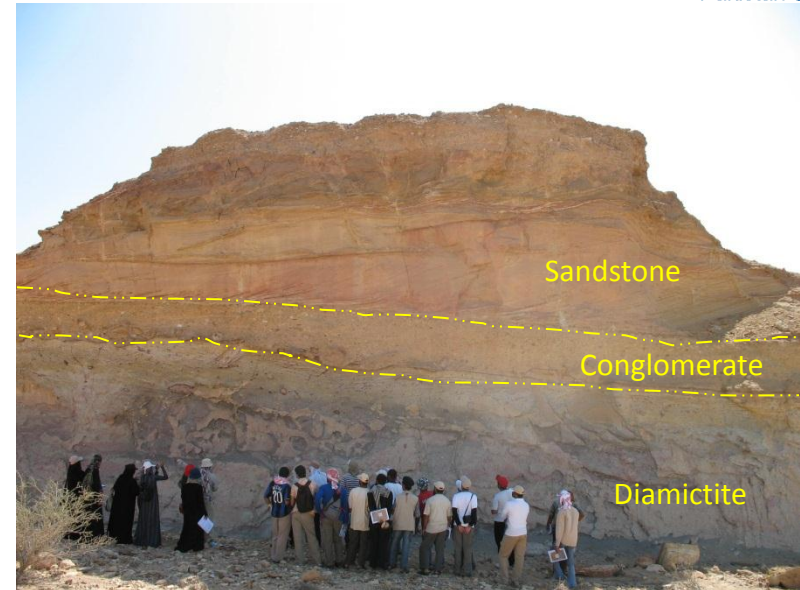
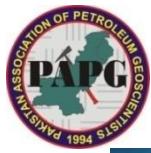
# Lithofacies: Tobra Formation



# Lithofacies: Tobra Formation



# Lithofacies: Al-Khlata Formation



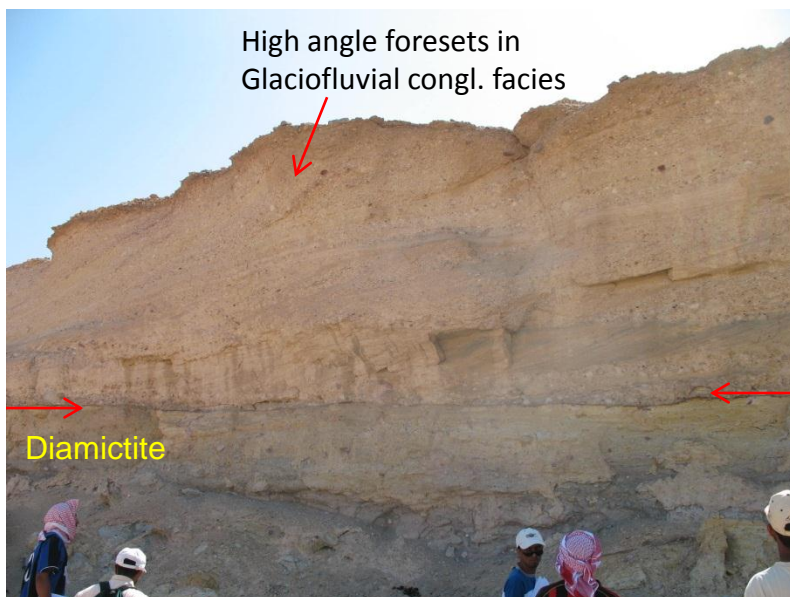
# Lithofacies: Al-Khlata Formation

Diamictite

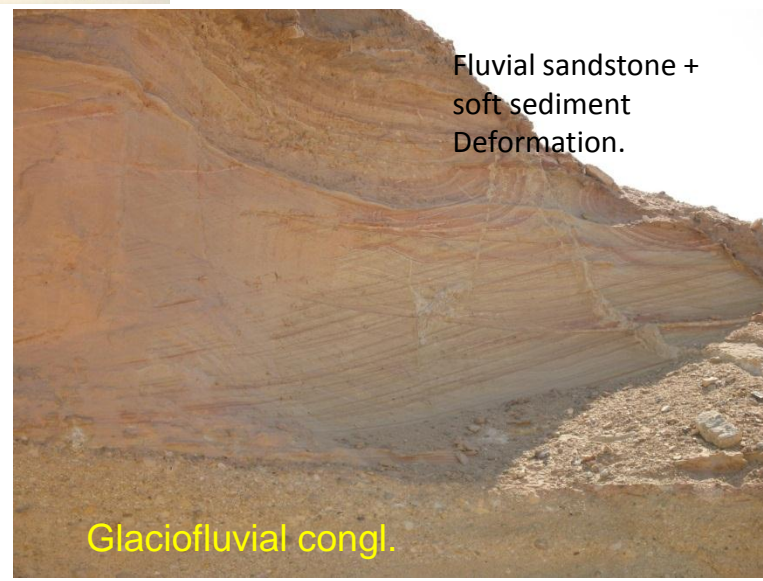


Diamictite facies in cores.  
The glaciogenic facies are  
widespread in subsurface

High angle foresets in  
Glaciofluvial congl. facies



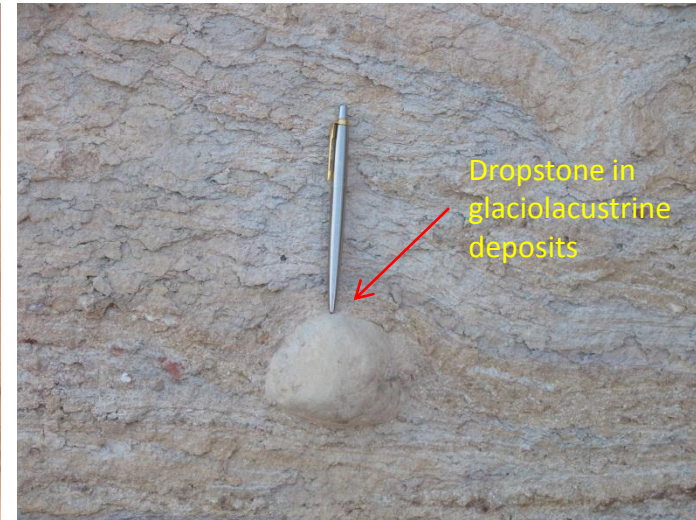
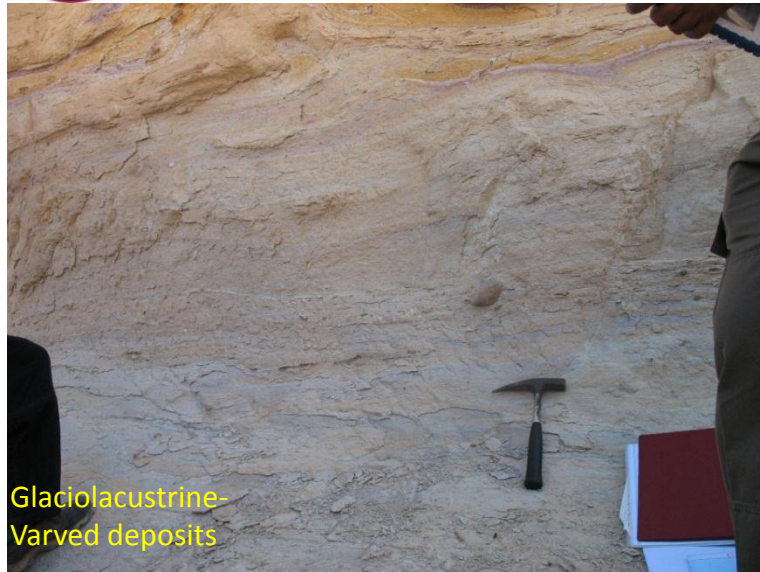
Diamictite



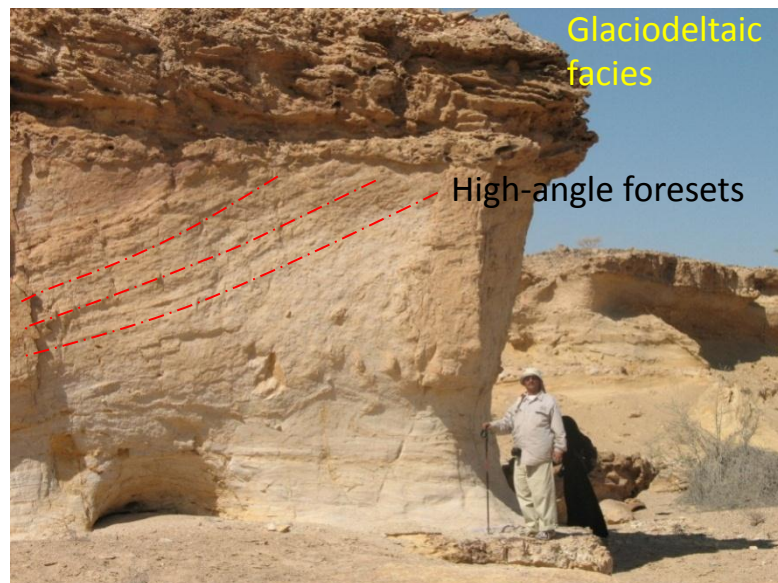
Fluvial sandstone +  
soft sediment  
Deformation.

Glaciofluvial congl.

# Lithofacies: Al-Khlata Formation



Glaciolacustrine facies  
in subsurface

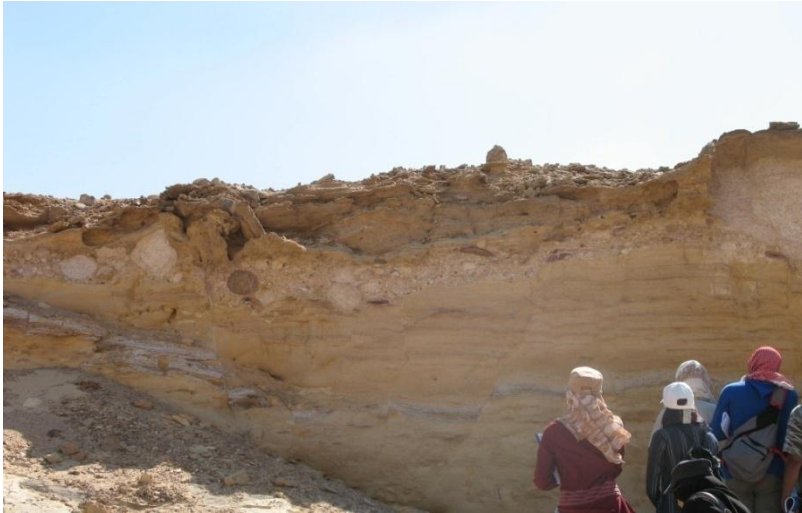


# Soft-sediment deformation in Al-Khlata Formation

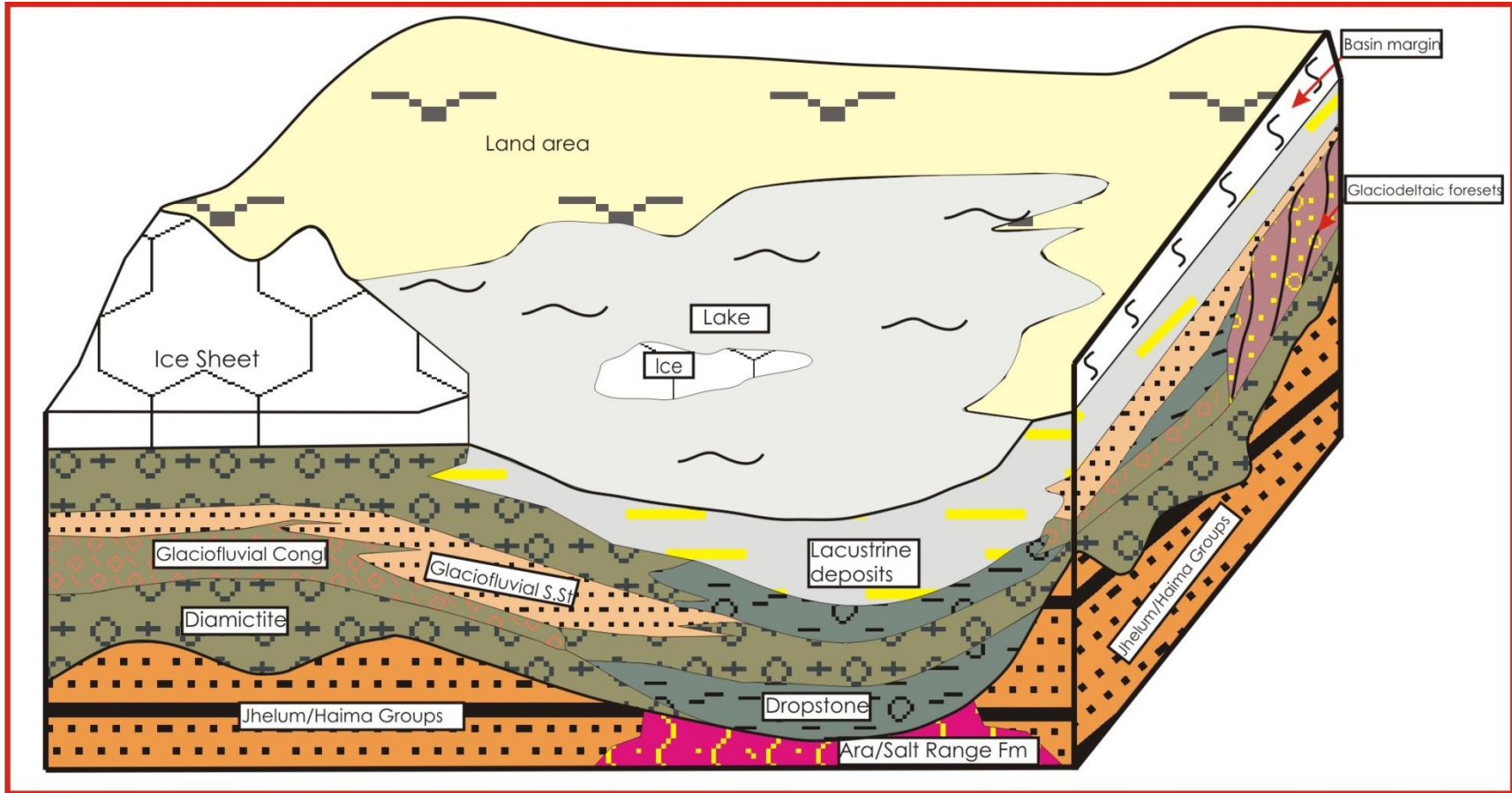
(In subsurface & outcrops)



50cm



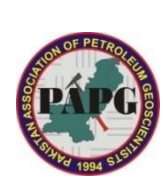
# Proposed Depositional System of Tobra & Al-Khlata Formations



# Lithofacies of Warchha & Gharif Formations

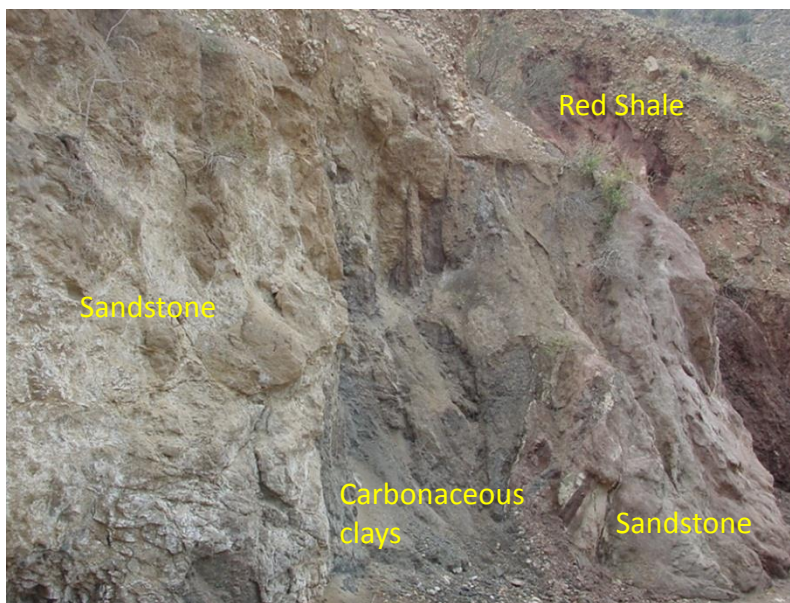
## Fluvial facies including

- Braid Bar facies
- Meander belt facies
- Channel facies
- Coastal Plain facies

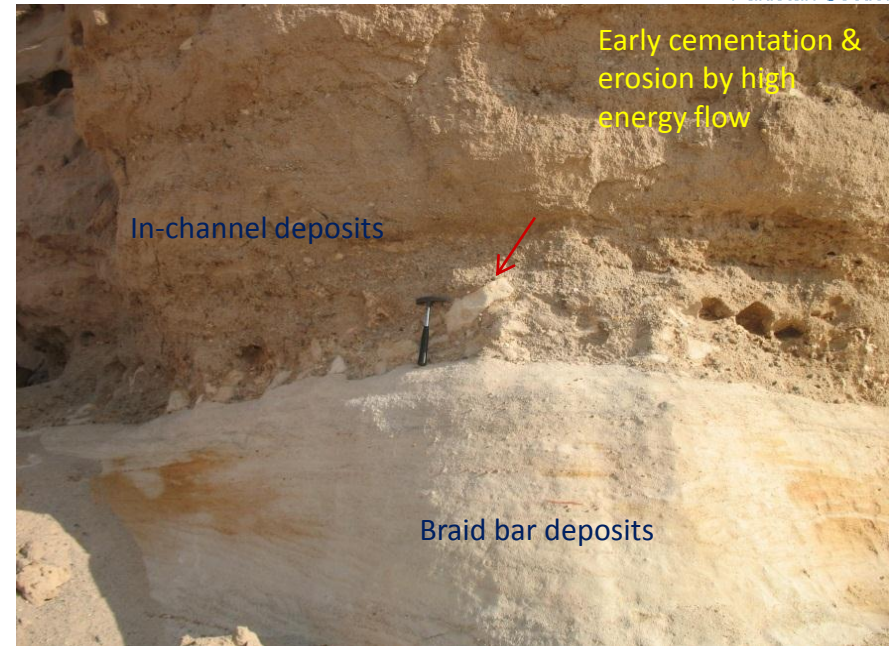
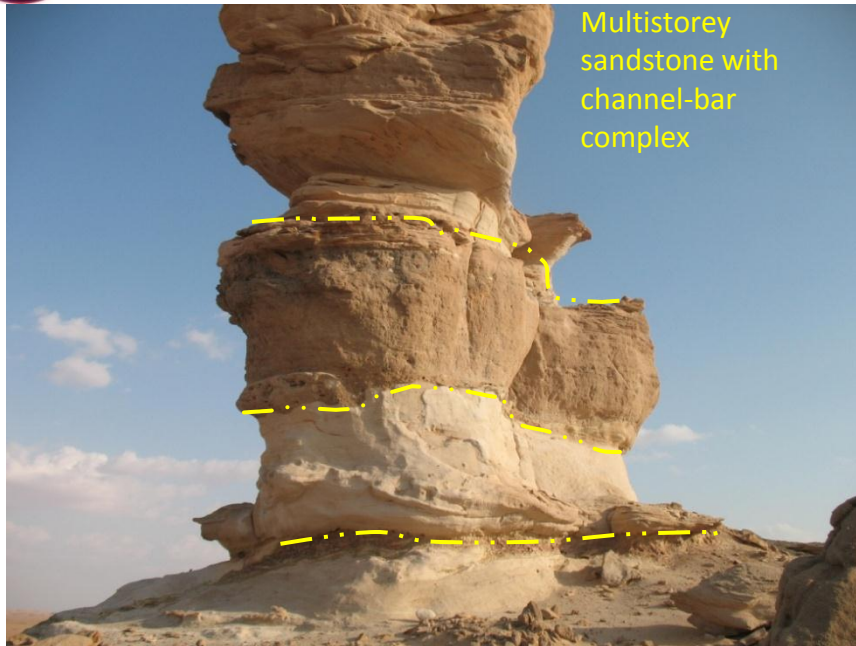


# Lithofacies: Warchha Formation

View of Warchha Fm-Zaluch Nala



# Lithofacies: Gharif Formation



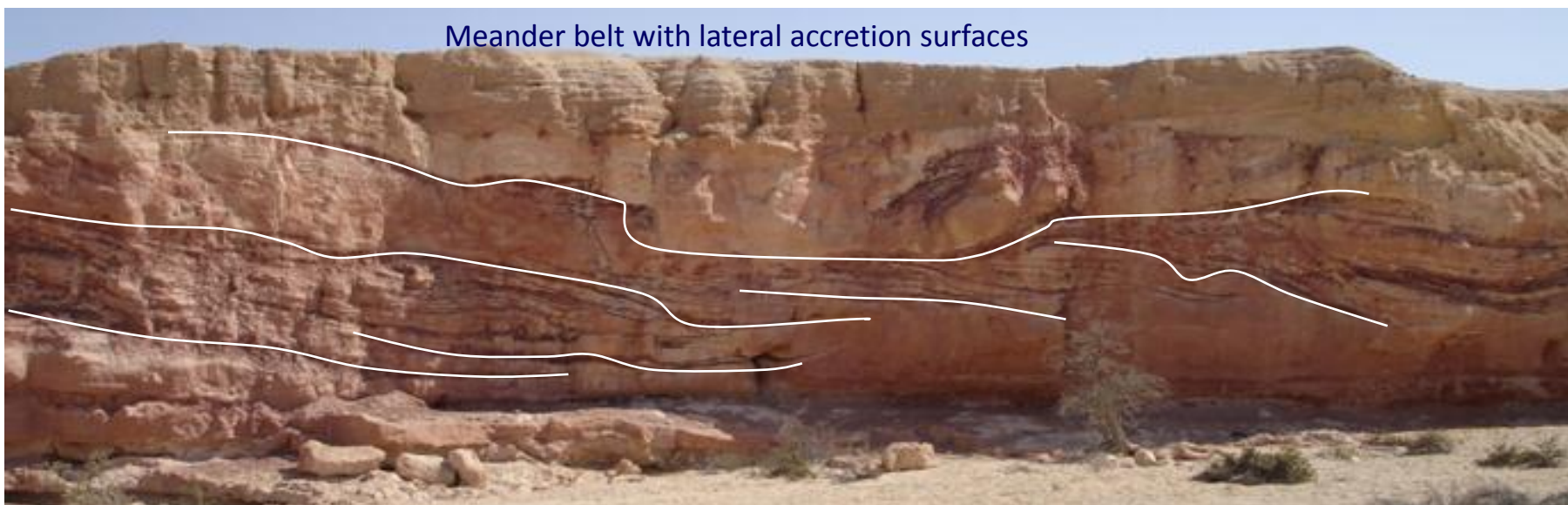
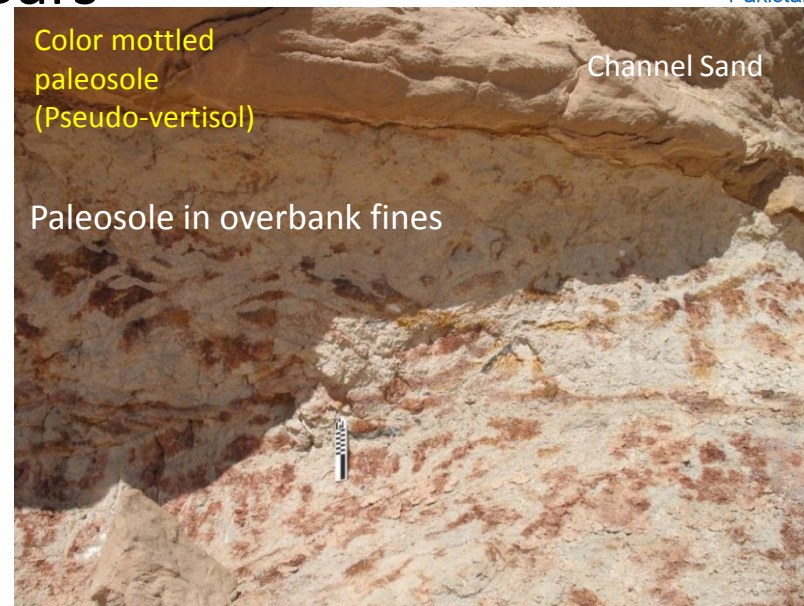
# Lithofacies: Gharif Formation-Lower Part

## Braid Bars

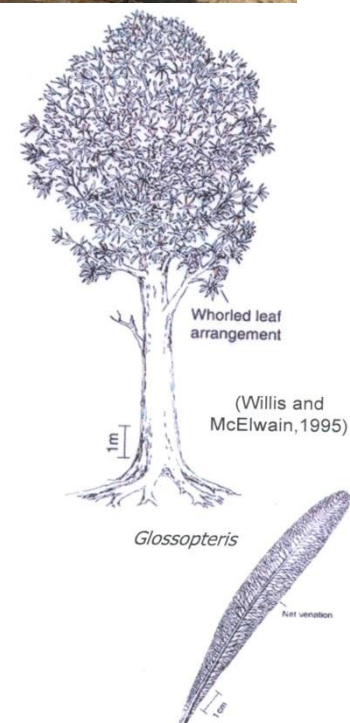
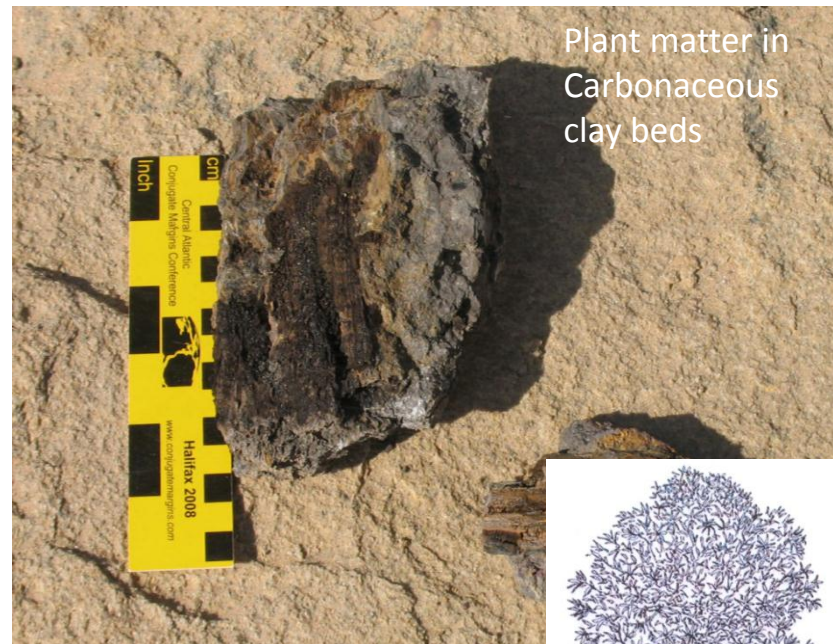
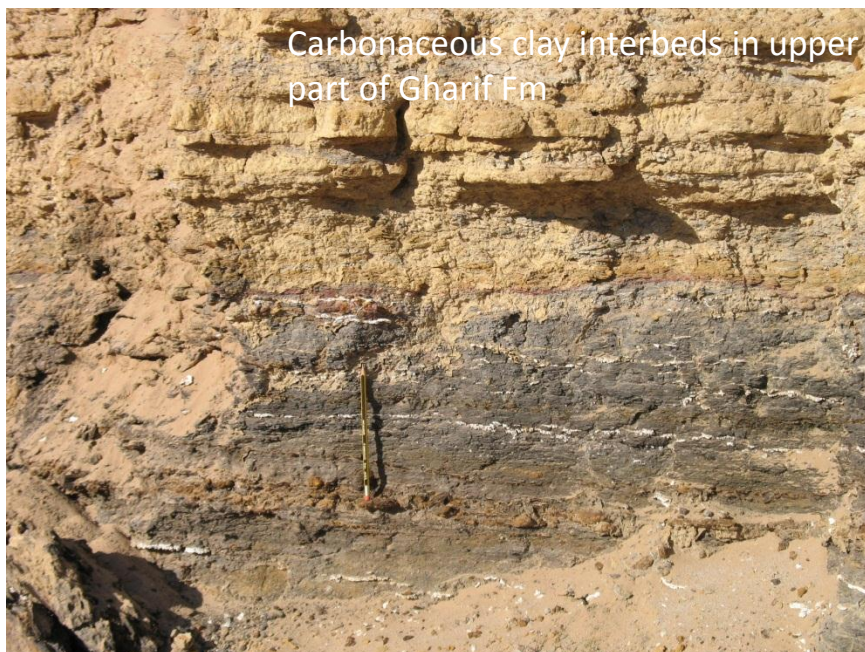


# Lithofacies: Gharif Formation-Upper Part

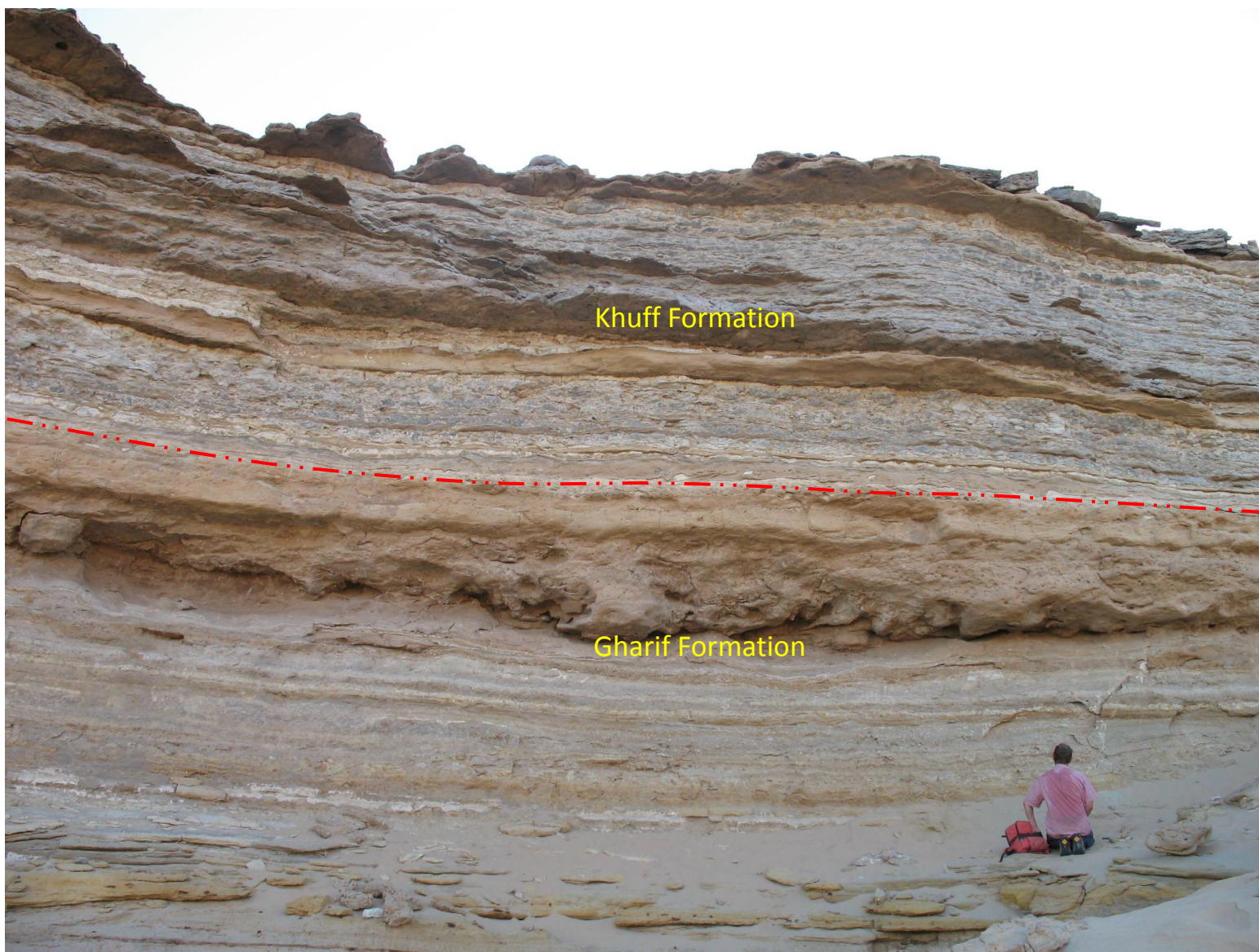
## Point Bars



# Lithofacies: Gharif Formation-Upper Part Coastal Plain

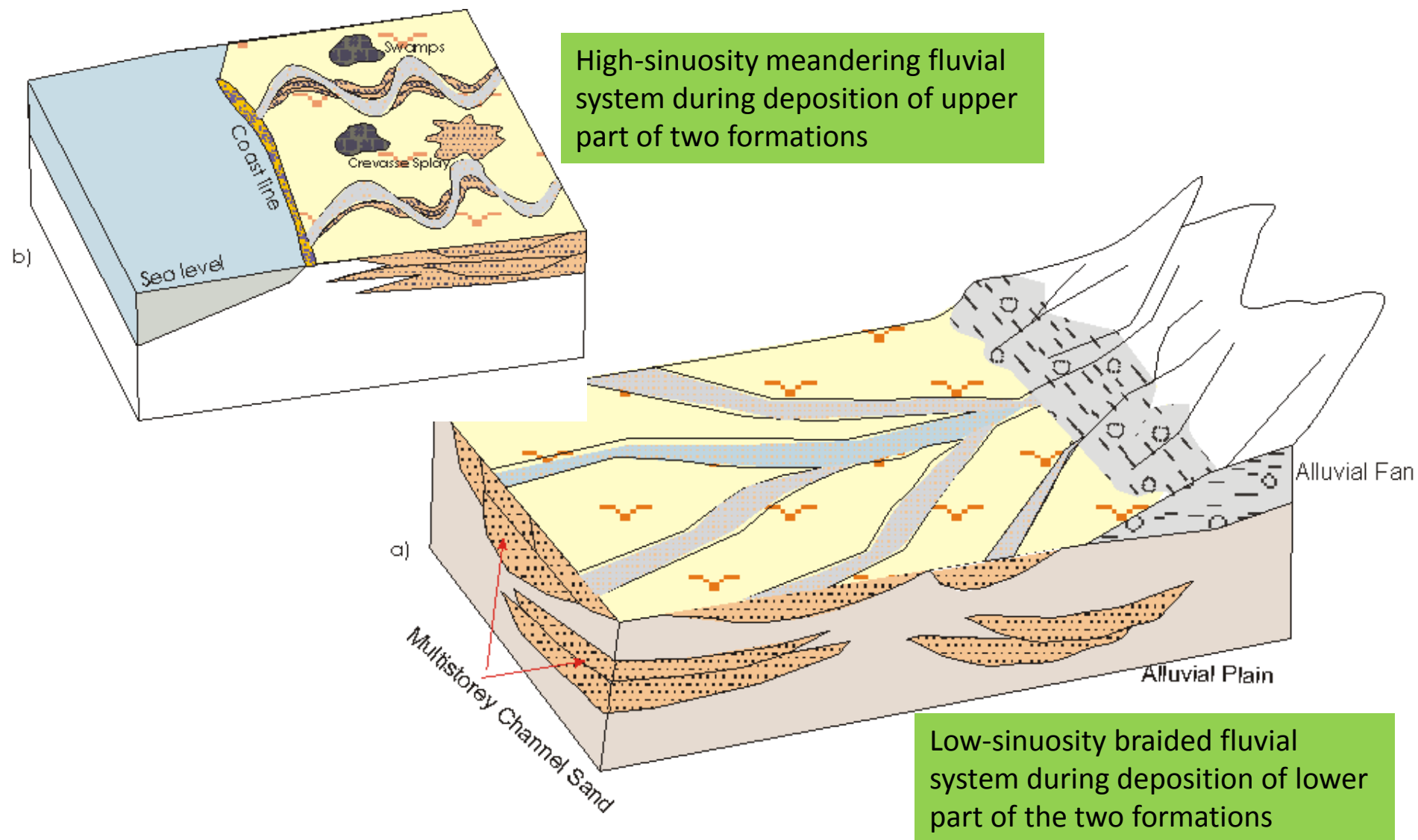


# Upper Contact of Gharif Formation with Khuff Formation Carbonates



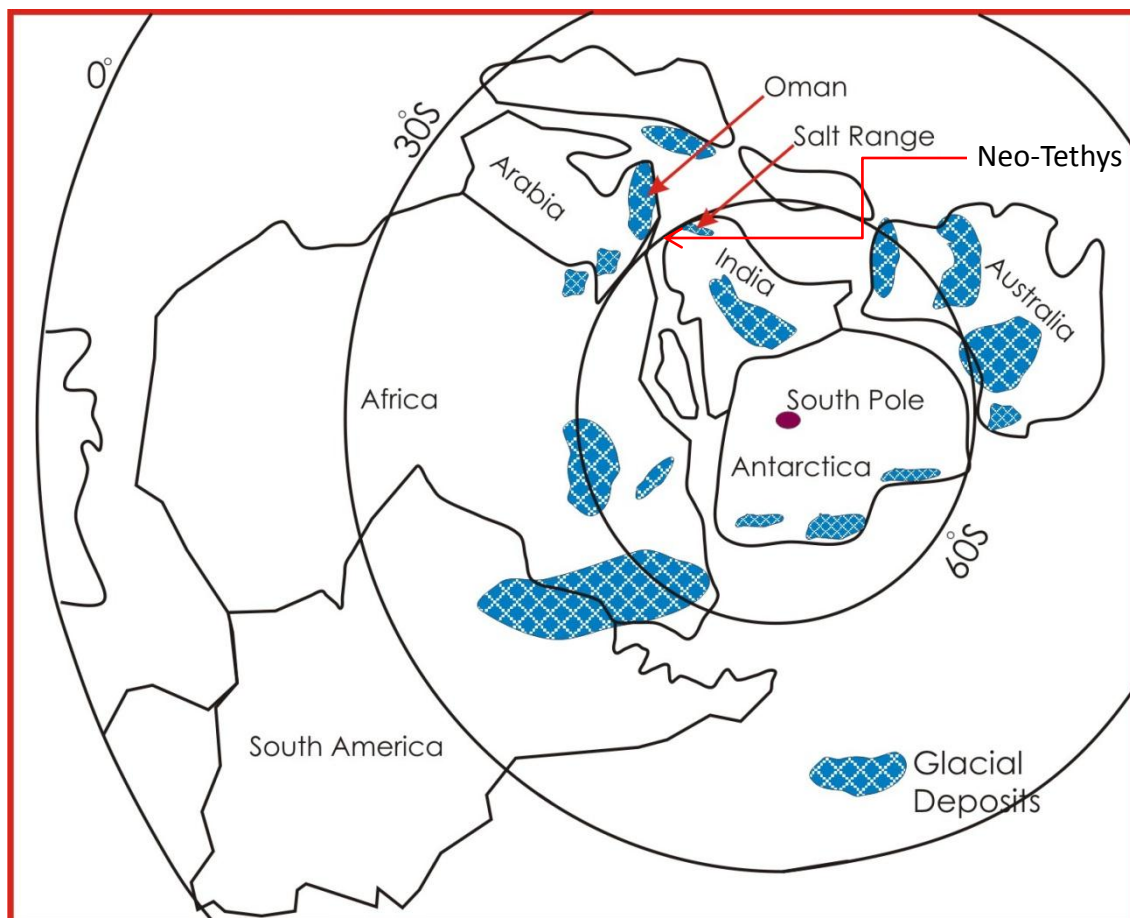
Transitional contact passing through coastal plain swamps, estuarine, bioclastic sandstone to carbonate facies

# Proposed Depositional System of the Warccha and Gharif Formations

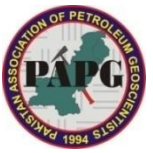




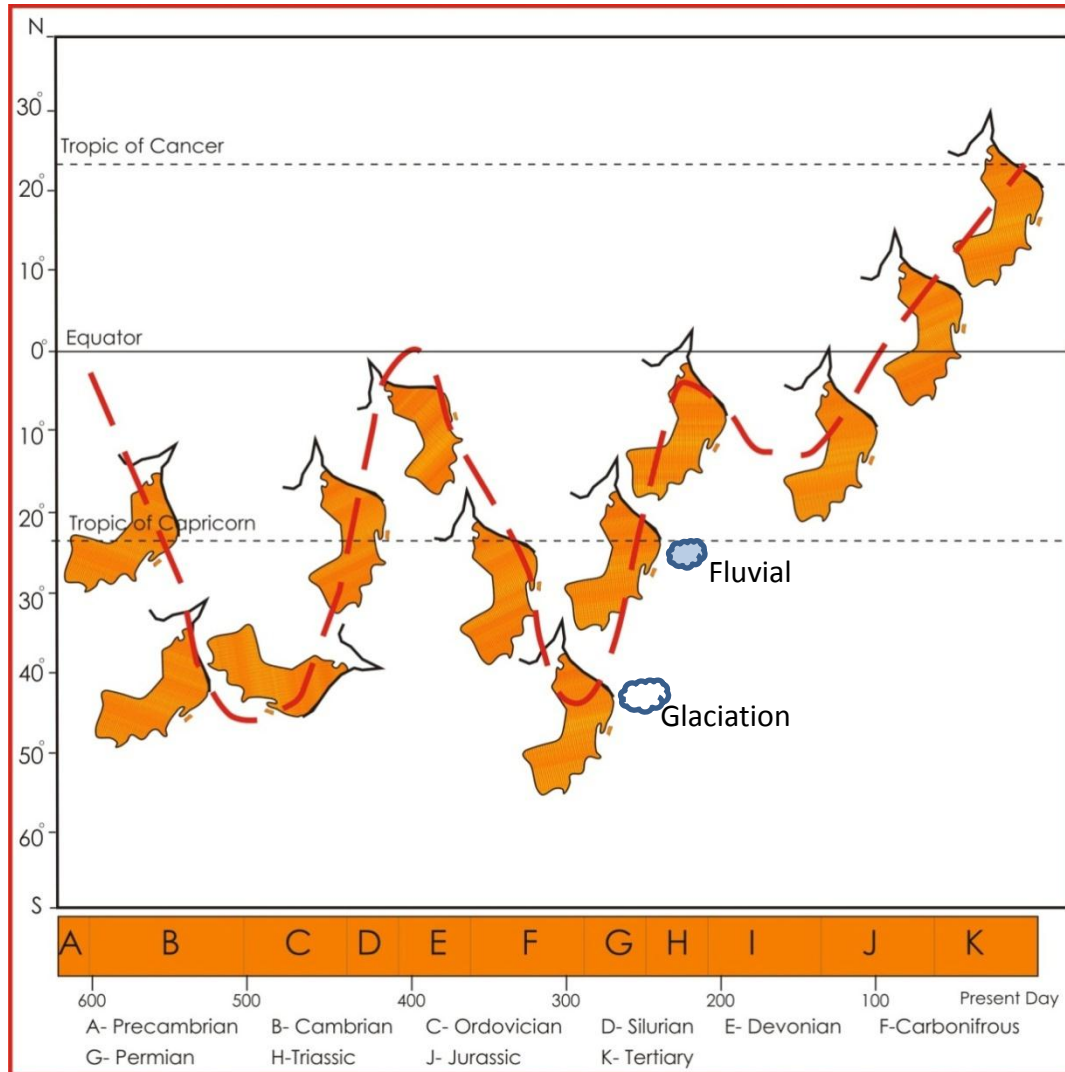
# Paleogeography of Gondwanaland with special reference to Oman and Salt Ranges during Late Carboniferous-Early Permian glaciation in southern hemisphere. Both areas were located at about 50° S



After  
 Scotese et al., 1979;  
 Levell et al., 1988



Proposed latitudinal positions of Oman from Precambrian to Recent. About 50° S during deposition of Al-Khlata Formation, while drifted to 20° S by the Gharif time



Konert et al.,  
2001

# CONCLUSIONS

- The Upper Paleozoic siliciclastic rocks of the Nilawahan and Haushi groups despite being deposited in different basins share great similarity in their lithofacies assemblages and depositional system due to their similar tectonic setting in north Gondwanaland.
- The glacial (Al-Khlata) and fluvial (Gharif) sediments in Oman Interior Basin are much thicker than comparable sediments (Tobra & Warchha Fms) in Salt Range areas is probably due to large ice sheet occupied Omani part as compared to Salt Range area.
- The glacial and associated sediments were deposited when depositional sites were located near South Pole ( $50^{\circ}\text{S}$ ).
- The fluvial deposits formed as these areas drifted northward and rifting of the north Gondwanaland started leading to the opening of the Neo-Tethys ocean.

*Thank you*

