

Detachment Tectonics and Its Implication for the Hydrocarbon Exploration In Western Kohat Foreland Basin, Northwest Himalayas, Pakistan*

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Abstract

This study presents the outcome of structural mapping and modeling conducted in the western Kohat foreland basin located in northwest Himalayas, Pakistan and have better constrained the structural events, the quantification and nature of multiple detachments and the geometric relationship between surface and subsurface hydrocarbon bearing rocks. The structural style of the western Kohat foreland basin is typical of thin-skinned deformed terrains and is mainly controlled by a couple of regional scale structural detachments, confined to base-Precambrian and Eocene rocks. These detachments divide the stratigraphic sequence of the Kohat foreland basin into two structural-stratigraphic domains. The lower domain consists of a mechanically rigid succession of Cambrian to Paleocene rocks fabricated by a series of south-verging, fault-propagation folds which constitute the main hydrocarbon play of the region. The upper structural-lithologic domain is relatively more ductile and is comprised of Eocene to Pliocene rocks fabricated by tightly folded, internally thrust and doubly overturned anticlines separated by broad synclinal lows. The east west trending surface structures developed in the upper domain are related to detachment thrusting in the Eocene rocks. The total amount of shortening is found to be 36% for the lower domain and 25% for the upper domain, suggesting shear along the base-Eocene detachment. The two domains have deformed disharmonically; hence the geometry of surface anticlines does not imitate the geometry of subsurface hydrocarbon bearing anticlines.

Selected References

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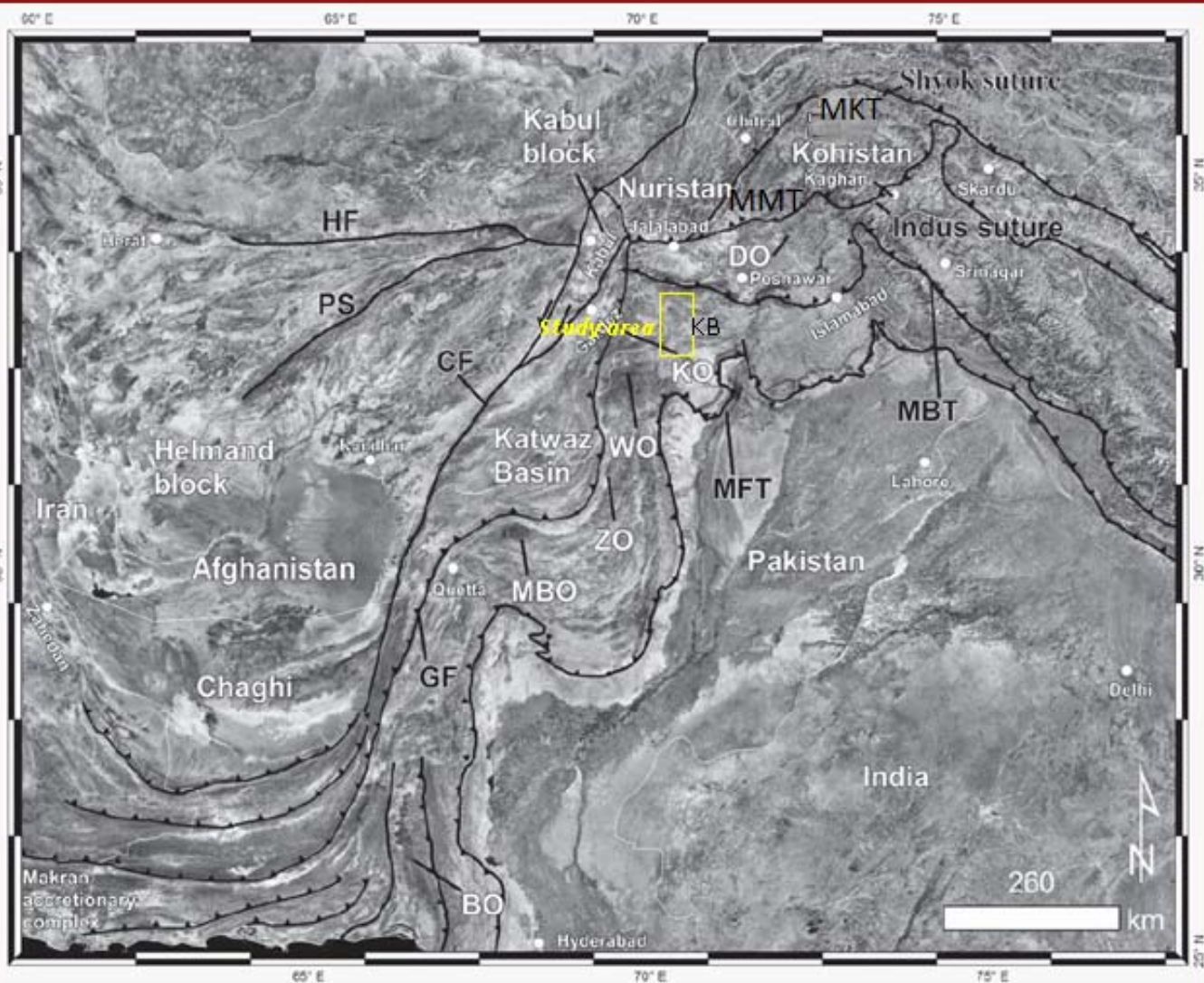
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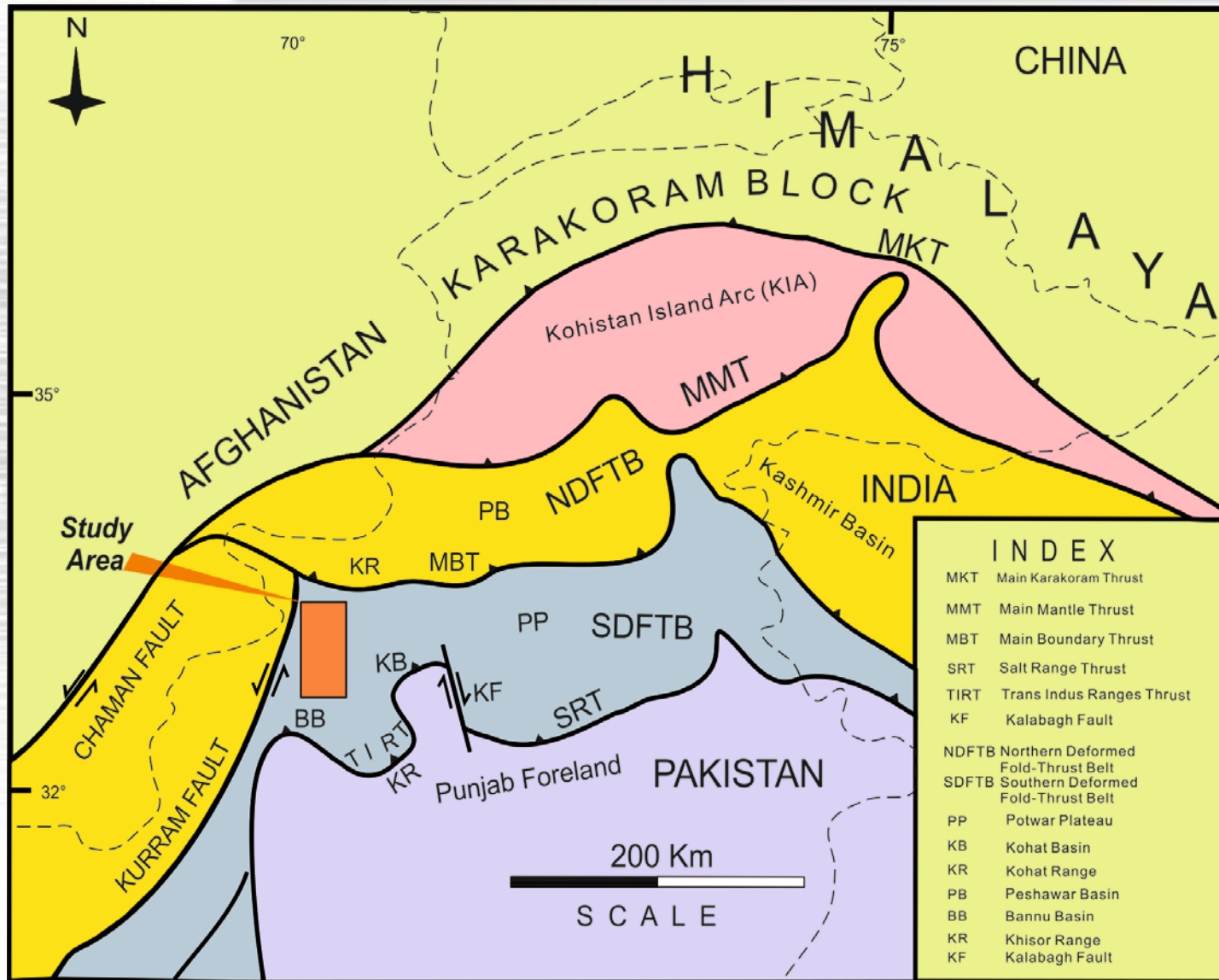


Land sat. showing Regional Tectonic Features of Pakistan (after Khan et al., 2009)

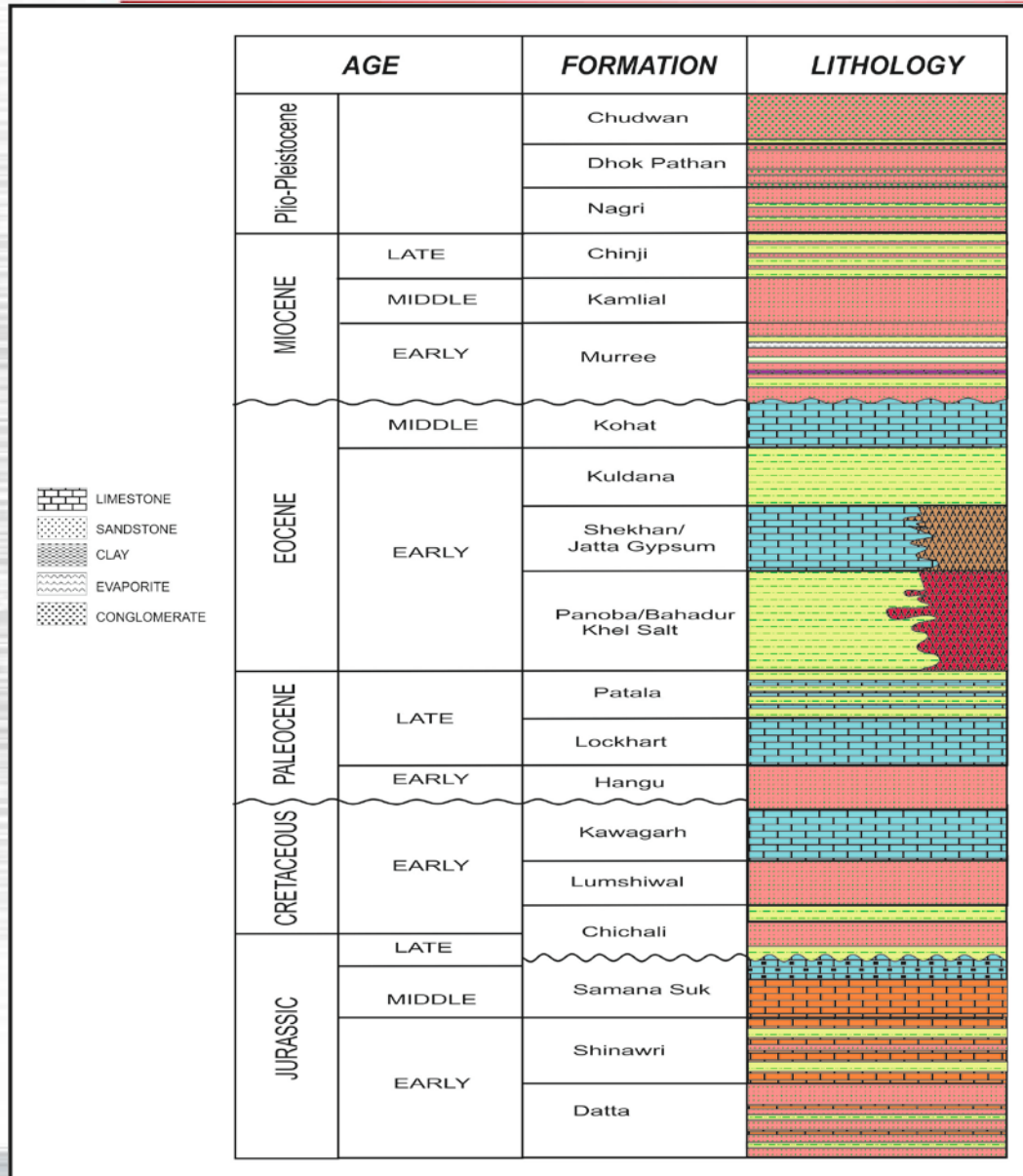


BO—Bela Ophiolite;
MBO—Muslim Bagh ophiolite;
ZO—Zhub ophiolite;
SR—Sulaiman ranges;
WO—Waziristan ophiolite;
KO—Khost ophiolite;
KB—Kohat Basin;
DO—Dargai ophiolite;
GF—Ghazband fault;
CF—Chaman fault;
PF—Panjao shear;
HF—Herat fault;
MFT—Main Frontal thrust;
MBT—Main Boundary thrust;
MMT—Main Mantle thrust;
MKT—Main Karakoram

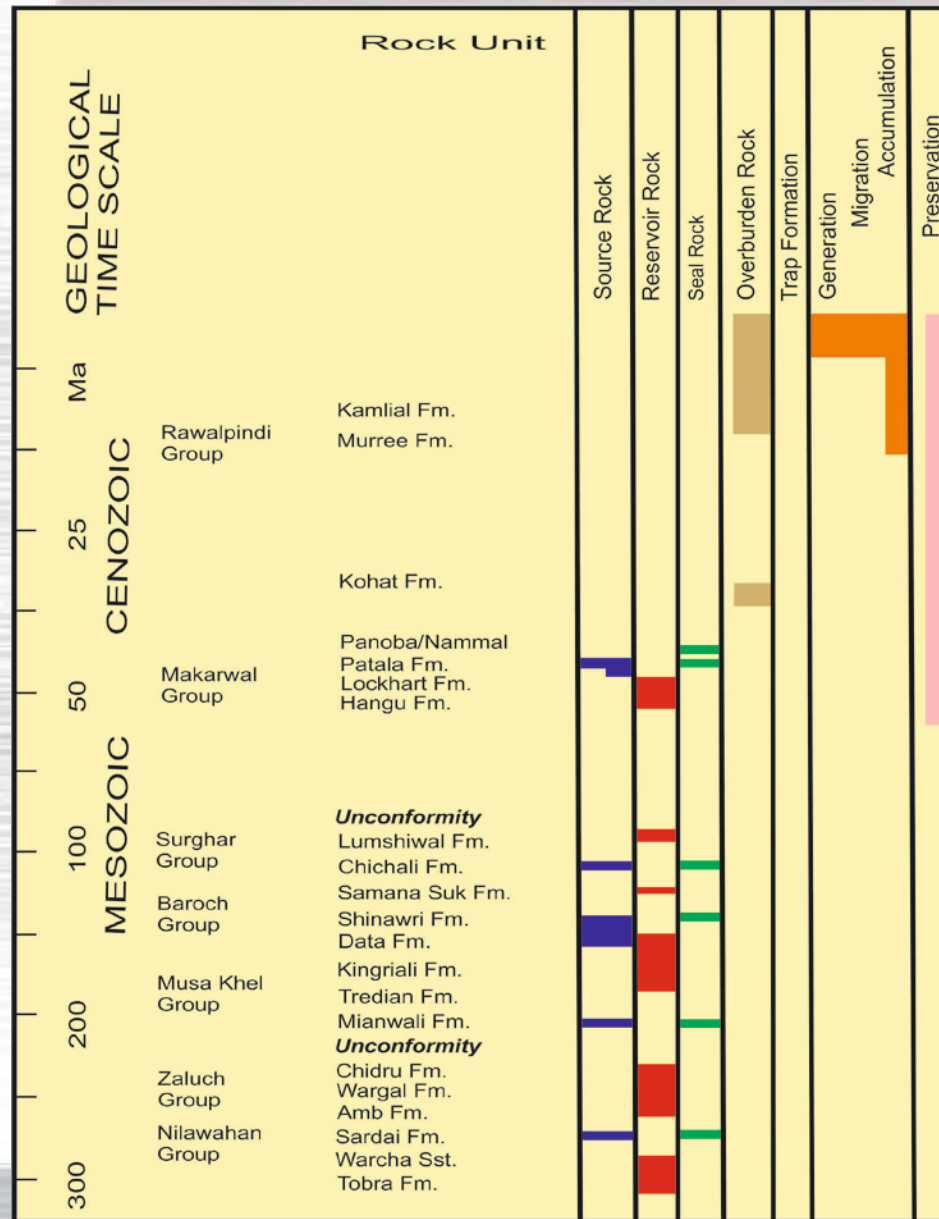
Structural map of North Pakistan (modified after Kazmi & Rana, 1982)



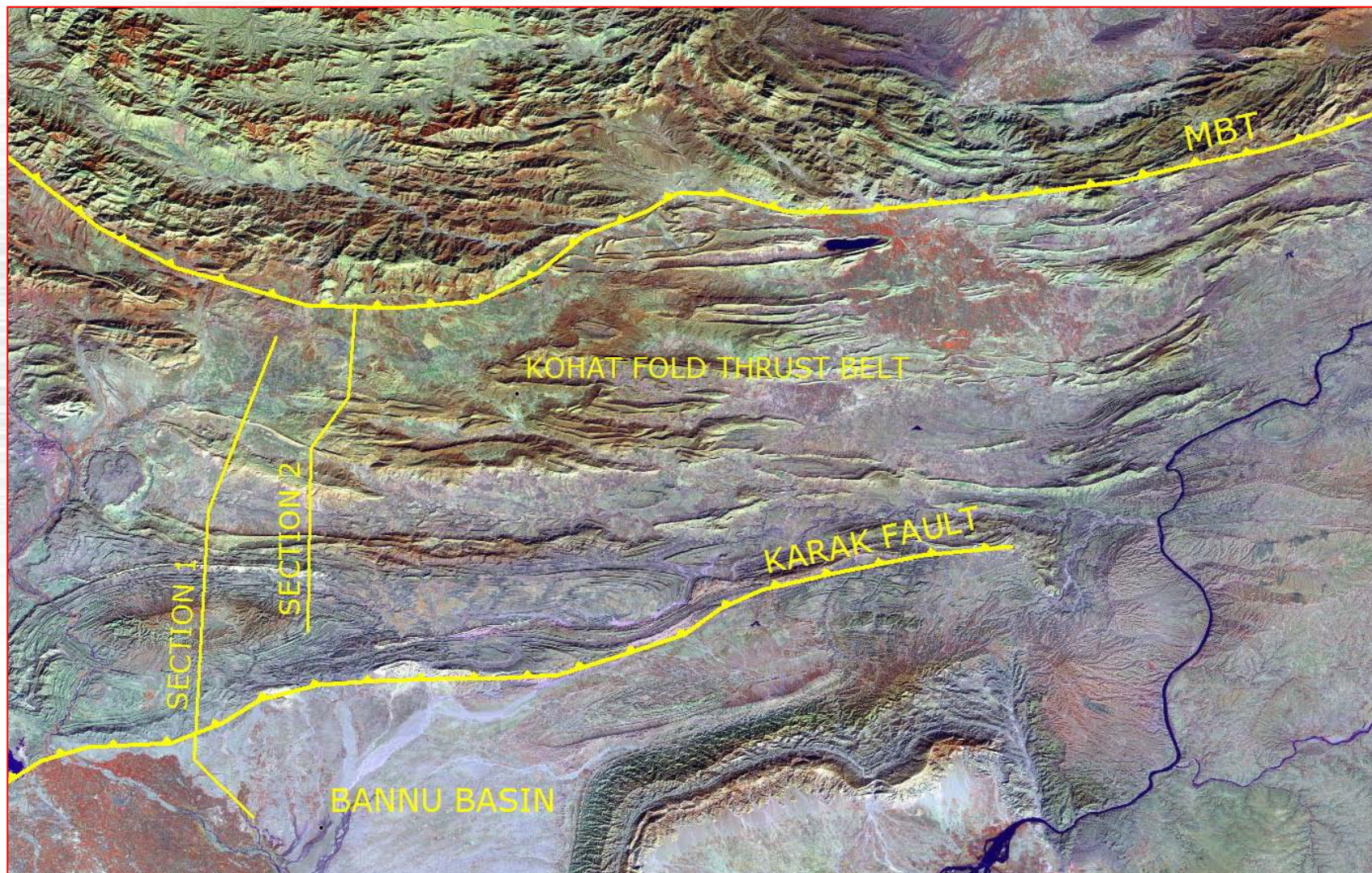
Generalized Stratigraphic column of the Kohat Foreland Basin



Proven Petroleum System of the Kohat Foreland Basin



Land Sat showing structural fabric and location of studied Transects



- Model 1: Structures within exposed rocks are part of a passive roof thrust underlain by an active wedge of south directed thrust slices of pre Tertiary rocks (Abbassi & Mc Elroy, 1991)**
- Model 2: Deep rooted Strike slip faults are exposed at surface as doubly overturned tight anticlines (Pivnik & Sercombe, 1993)**
- Model 3: Decollement related thrusting within Paleocene and older rocks tip at the base of Eocene sequence which itself has been deformed disharmonically (Ahmad et al, 2003)**

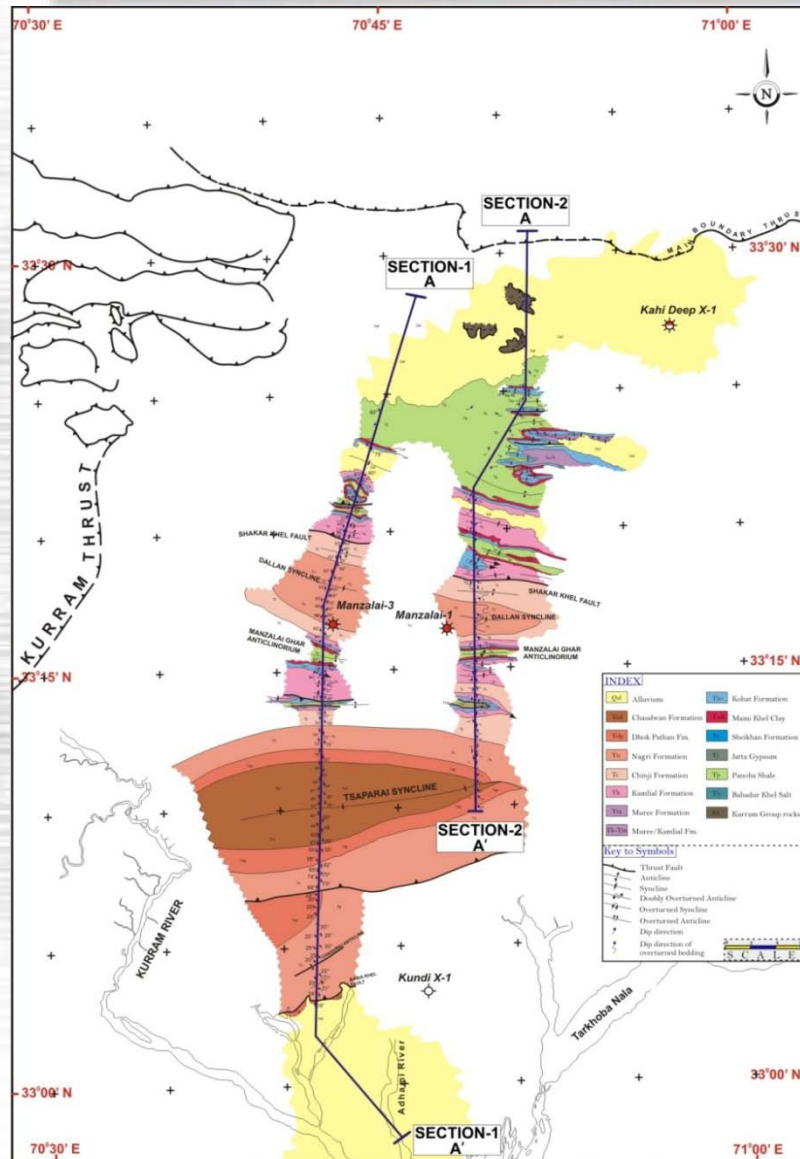


Objectives of this Study

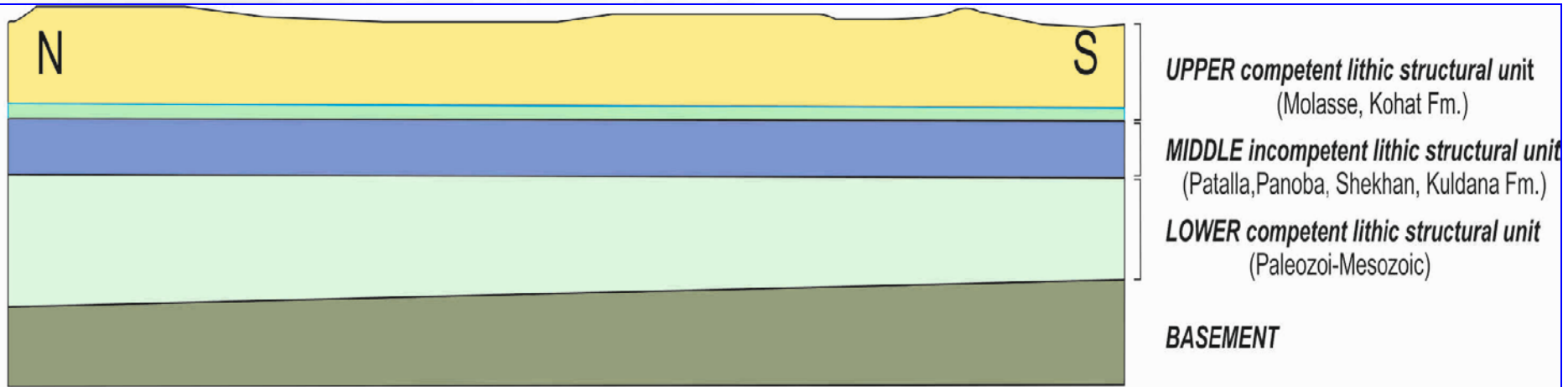
- ☐ To integrate the surface and sub-surface data in order to better understand the structural style of the Kohat Foreland Basin
- ☐ To validate the structural style of the Kohat Foreland Basin through Structural Restoration



Geological map along Seismic Transects



Mechanical Stratigraphy of the Kohat Foreland Basin



Available Data for Restoration

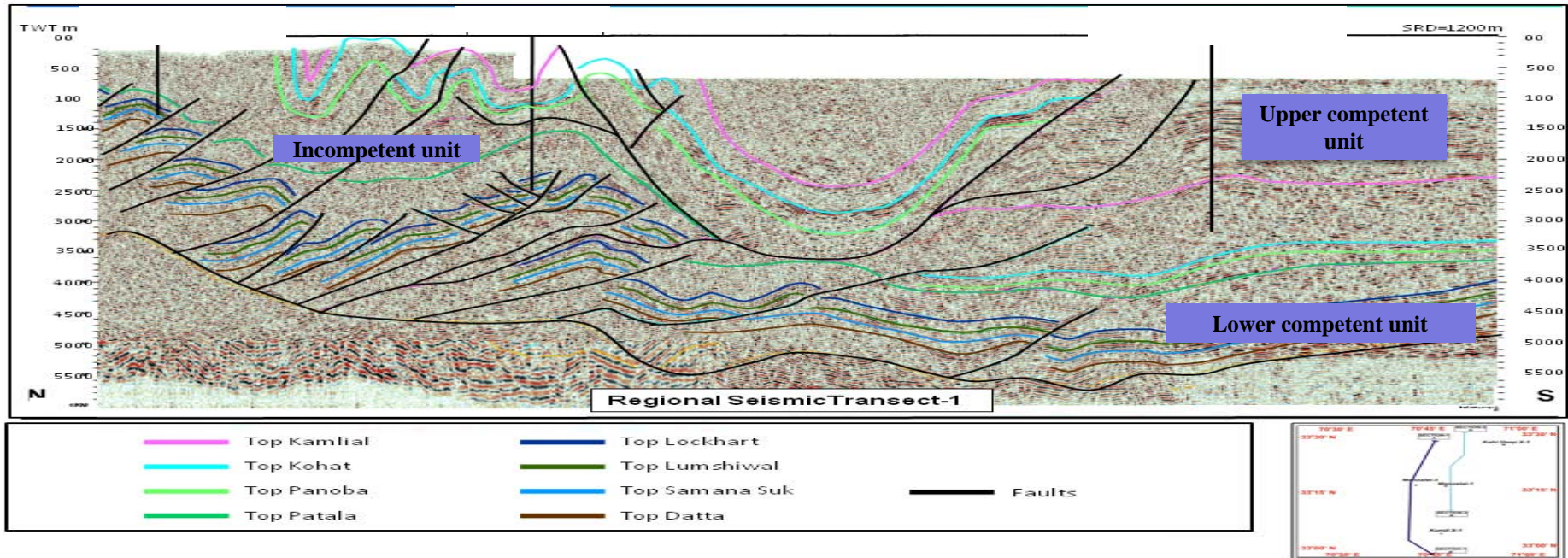
Main Available Data

The following data was used for the restoration work:

- Geological sections
- Seismic data
- Well data and sedimentology to better constrain the geometry of thrust faults and the thickness of the stratigraphic Units.



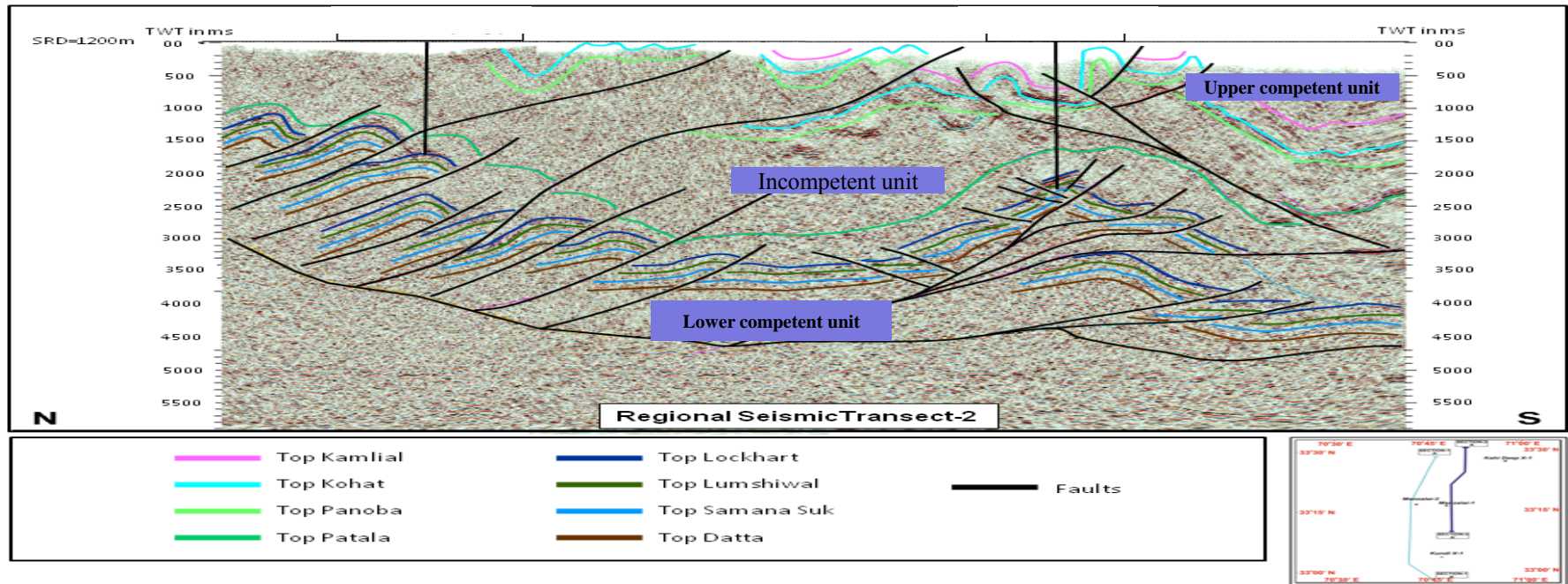
Horizon and Structural interpretation on regional seismic Transect-1



- A lower detachment developing flat in Infra-Cambrian
- An upper detachment developing flat into Panoba Shale

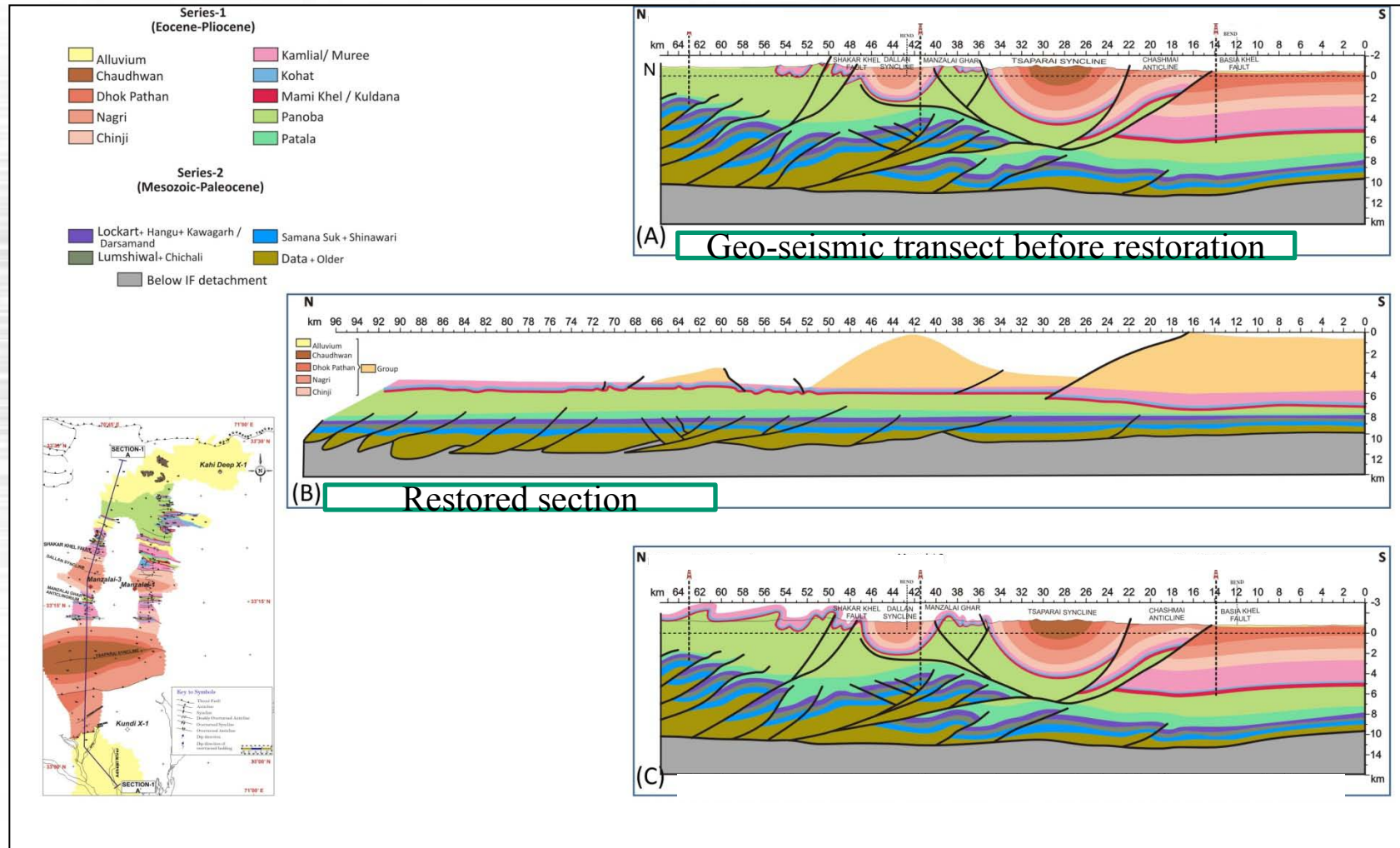


Horizon and Structural interpretation on regional seismic Transect-2



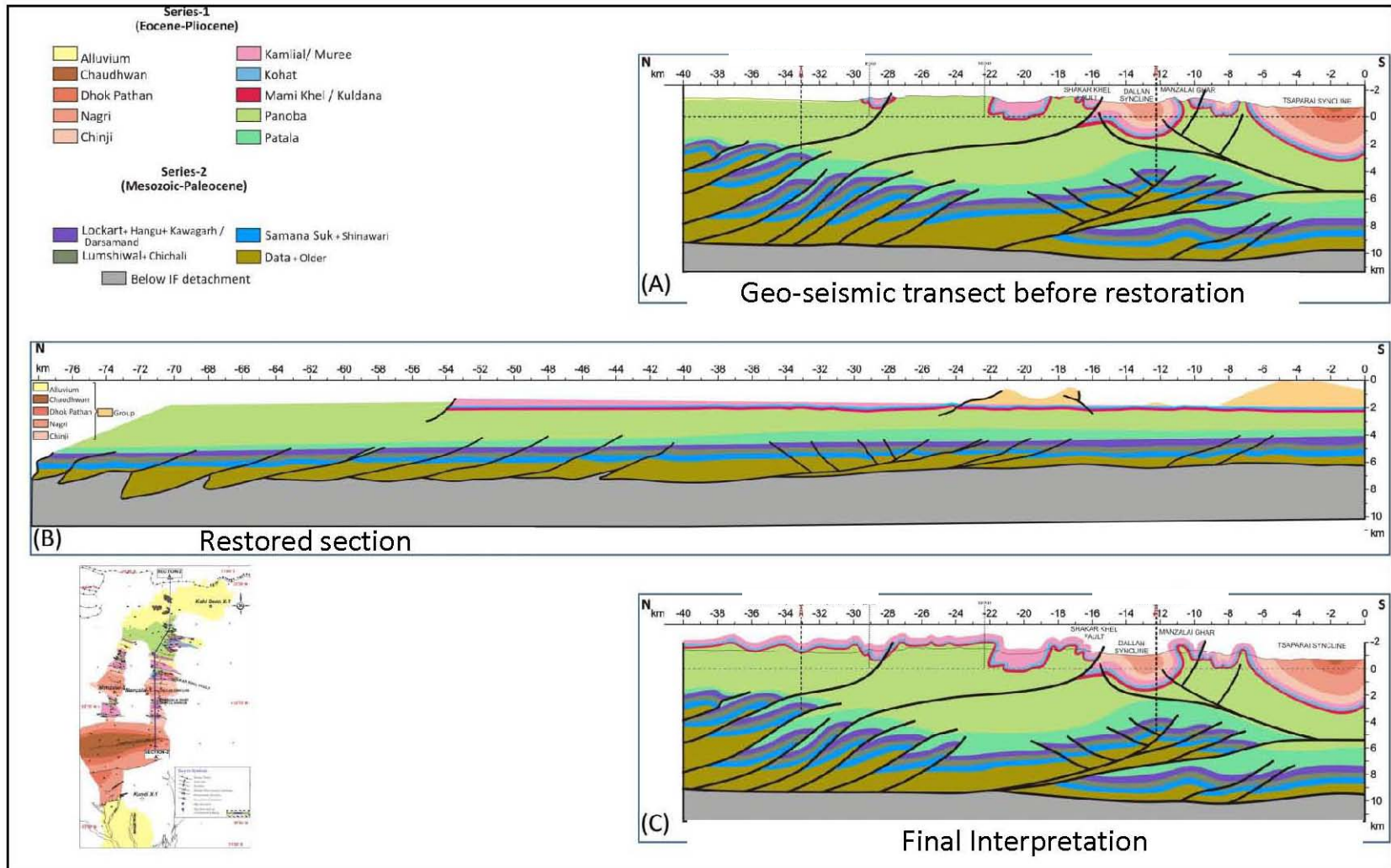
- *A lower detachment developing flat in Infra-Cambrian*
- *An upper detachment developing flat into Panoba Shale*

Geo-seismic transects and restoration of section 1

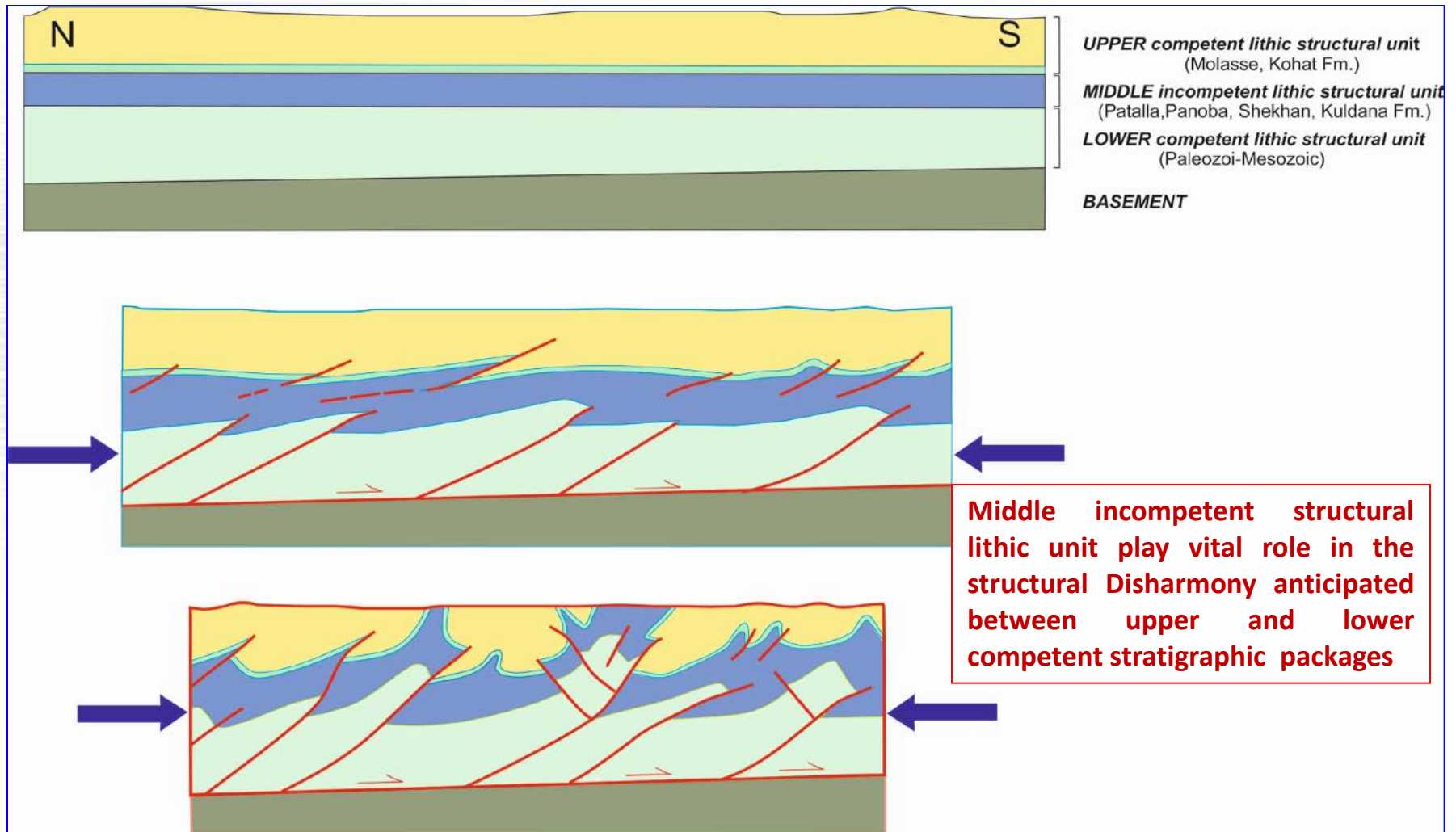


• The total amount of shortening is found to be 34-35% for the lower series whereas it is about 26-27% for the upper series

Geo-seismic transects and restoration of section 2



Kohat Foreland Basin structural Model



Conclusions

There are Two major detachments play a major role in defining structural style of Kohat foreland basin:-

**(i)Infra Cambrian having 1.4-1.5° initial dip to the north
&**

(ii) Eocene shale/evaporites

- A lower structural series (Mesozoic) encompasses about 2000m thick, relatively rigid, sequence of Cambrian to Paleocene rocks and comprise the proven petroleum system of the area**
- The upper structural series is comprised of more ductile Tertiary rocks having variable thickness in the range of 2000-4000m. The “Tertiary” series is characterized by tightly folded, often internally thrust anticlines, which are mostly overturned to the south**
- The surface structures, which trend E-W, are related to detachment thrusts developing in the Eocene series**
- The two stratigraphic cum structural series dictate different deformational behavior and structural style, deforming completely “disharmonically.**