Geol. Bull. Univ. Peshawar, Vol. 38, pp. 149-156, 2005

Sargodha High: A Flexure Forebulge of the Himalayan Foreland Basin

MUHAMMAD IRFAN, MUHAMMAD SHAHID, MUHAMMAD HAROON
& NAZAR ABASS ZAIDI
Oil and Gas Development Company Limited (OGDCL), Pakistan

ABSTRACT: *Foreland basins are characterized by down warps due to orogenic overloading and flexure forebulge at the periphery. The uplifting and shifting of flexure bulge results in the erosion of sediments and ultimately presence of unconformity in the stratigraphic record. Interpretation of seismic and geological data reveals that Sargodha High is a flexure bulge of the Himalayan foreland basin and has resulted Oligocene hiatus in the stratigraphic record. The stratigraphic gap at the base of Neogene mollase results from erosion of the former passive margin series during the Oligocene, but also from the progressive onlap of Miocene flexural series towards the foreland bulge. The proper identification of flexure forebulge unconformity aids in predicting petroleum play system in the enclosing sediments.*

INTRODUCTION

The foreland basins represent down warping of foreland plates by orogenic loading and exhibit characteristic asymmetry deepening toward orogeny and minor up warp due to flexure response at the periphery. These minor up warps around a foreland basins are known as flexure forebulges.

Compared to the basin, forebulge is a subtle feature as amplitude of subsidence in the basin is typically 20-40 times greater than the uplift of the forebulge (Crampton & Allen, 1995). Due to uplifting of forebulge, erosion of sediments takes place and unconformities are recorded in stratigraphic section.

On the continents several workers have attributed the basin margin unconformities to forebulge uplift. Crampton and Allen (1995) have recognized the fore bulge unconformity within North Alpine Foreland Basin (NAFB).

The Himalayan foreland basin also exhibits flexural bulge on its periphery (Fig. 1), the Sargodha-Delhi Ridge. Analysis of seismic and stratigraphic data reveal erosional unconformity in the foreland basin due to uplifting, resulting a typical stratigraphic gap increasing towards the forebulge.

DEVELOPMENT OF FORE BULGE AND CONSEQUENT UNCONFORMITY

The uplifting and advancement of bulge towards foreland is associated with the overloading and advancement of thrust sheets during early stage of foreland basin development (Crampton & Allen, 1995).

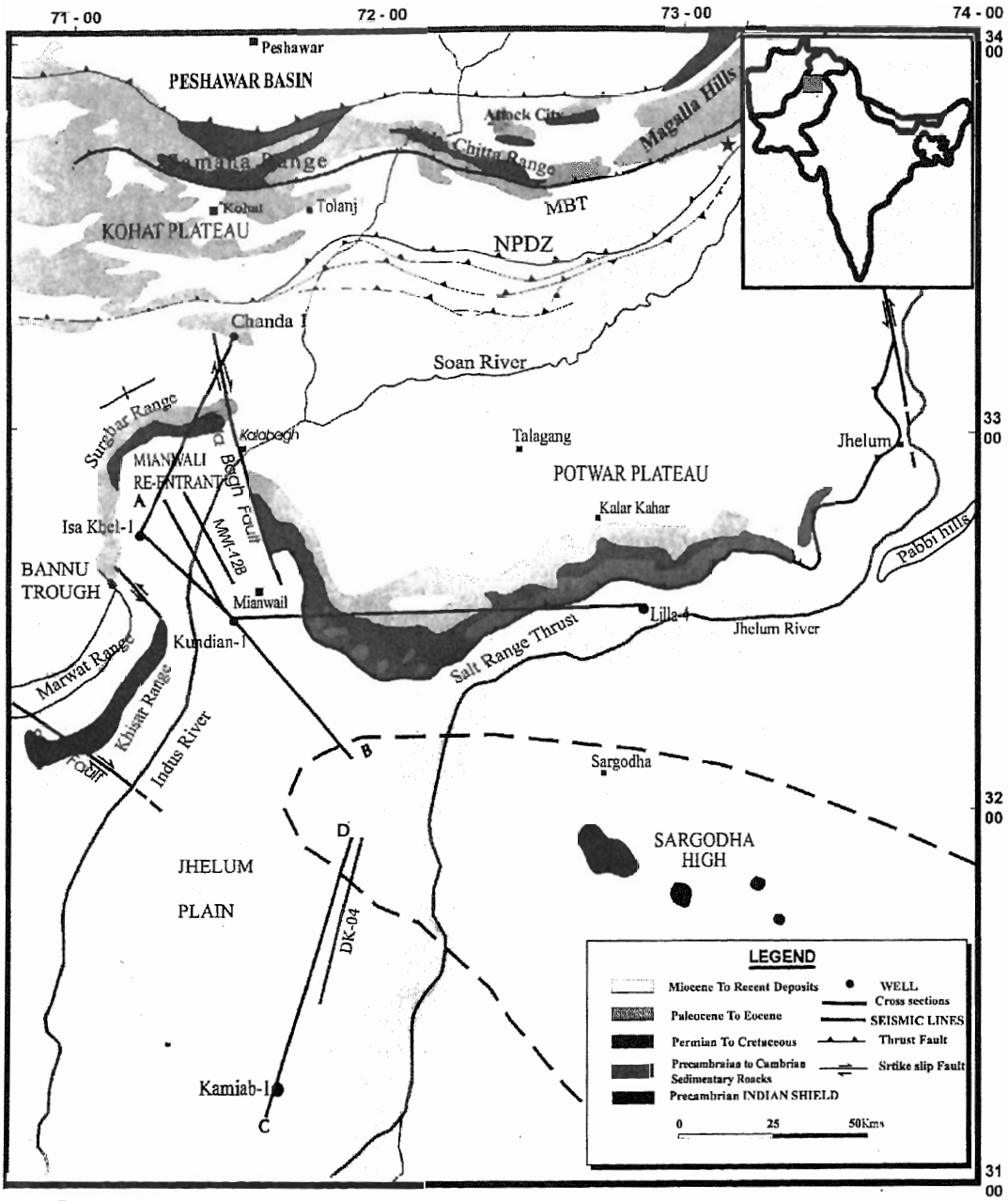

Fig. 1. Generalized Tectonic map of northern Pakistan, highlighting features of Himalayan Foreland and location of wells and seismic sections.

The Himalayan Foreland Basin (HFB) was formed when the frontal edge of the Indian Shield was overridden by south advancing nappes, 35Ma ago. The plate flexed down and the foreland basin received detritus from advancing Himalayan front

(e.g., Virdi, 1994). A minor bulge started emerging at the periphery. The Eocene carbonates at both sides of arch (Sargodha High) suggest that bulge was not prominent and shallow marine conditions prevailed in the area during Eocene time. After activation of Main Central Thrust (MCT) the bulge became prominent as nappes began to move southwards about 15Ma ago (Viridi, 1994). After the activation of Main Boundary Thrust (MBT) about 5Ma ago, the foreland basin got filled with sediments from Himalaya (Fig. 2), and due to suppression and smothering response the Sargodha Fore bulge was covered with Siwaliks and alluvium.

The erosional unconformity by the uplifting and shifting of Sargodha forebulge is exhibited in most part of HFB as base Miocene regional unconformity. As a result the Lower Tertiary and older sediments eroded and Precambrian basement got exposed. From seismic it is evident that sediments of early Eocene to Pre-Cambrian are gradually truncated below base mollase unconformity and Siwaliks onlap the unconformity (Fig. 3). The stratigraphic gap represented by the unconformity increases towards foreland and the largest gap is beneath the molasse basin where Miocene overlie Precambrian basement (Fig. 4). In the inner parts of the foreland basins the stratigraphic gap narrows and Miocene mollase overlie late Eocene carbonates. This rapid widening up of stratigraphic gap is maximum up to 400 m erosion away from the foreland basin is a typical characteristic of a forebulge unconformity (Fig. 5).

The widening of the stratigraphic gap towards high is due to progressively later transgression of younger basin fill deposits on the foreland plate combined with maximum erosion to the south.

Base Miocene forebulge unconformity shows distinctive major geometry of stratigraphic truncations, than that of Vailian type-1 unconformity. This allows the recognition of possible truncation trap and seal configuration. From paleogeograpic analysis of forebulge, explorationists can better predict stratigraphic geometries and facies distributions in the enclosing basin.

DISCUSSION

Forebulge and assosicated unconformities have not been recognized in the rock record. In fact sediments filling the basin suppress the fore bulge by spreading the load over a wider area (Coakley & Watts, 1991). Hence the amount of erosion at any point on the forebugle will be reduced if the basin is filled with sediments rather than with water. The suppression when continued for a longer time makes the bulge flatter and wider down to a sea level although the total erosion is decreased due to reduced height of the forebulge. In an overfilled continental foreland basin, the fore bulge is then easily buried by sediments supplied by orogeney. Hence, suppression and smothering of the forebulge by overfilling of the foreland basin may be the reason why forebulges have not been recognized associated with overfilled such as Himalayan (Indo Gangatic) foreland basin (Crampton & Allan, 1995). The conditions for suppression and smothering are most likely to be met in the latest stage of foreland basin development (Molasse stage) when the orogenic wedge starts to over ride the continental margin and become emergent (Stockmal et al., 1986; Sinclair & Allan, 1992). In case of Himalayan foreland basin 15Ma ago, MCT became active and the nappes become emergent started moving to the south and shedded Siwalik molasses to the foreland basin. The climax of which was reached 5Ma ago when MBT was activated. The activation of MBT filled the foreland basin with sediments and the DSR (forebulge) become covered with upper Siwaliks and alluvium.

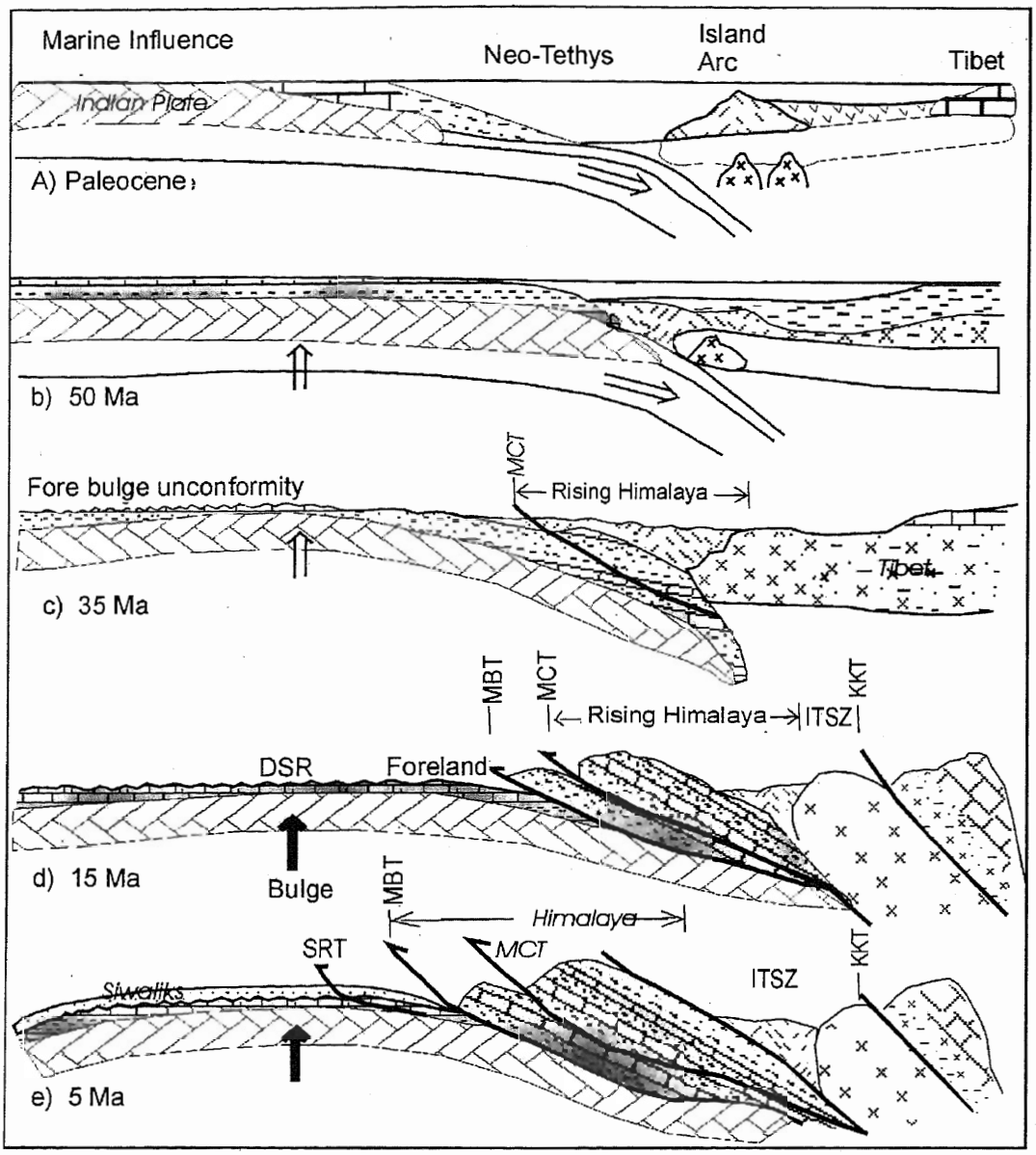

Fig. 2. Evolution of forebulge through time. DSR-Delhi Sargodha ridge, ITSZ-Indus Tsangpo Suture Zone, KKT-Karakoram Thrust, MBT-Main Boundary Thrust, MCT-Main Central Thrust (modified after Virdi, 1994).

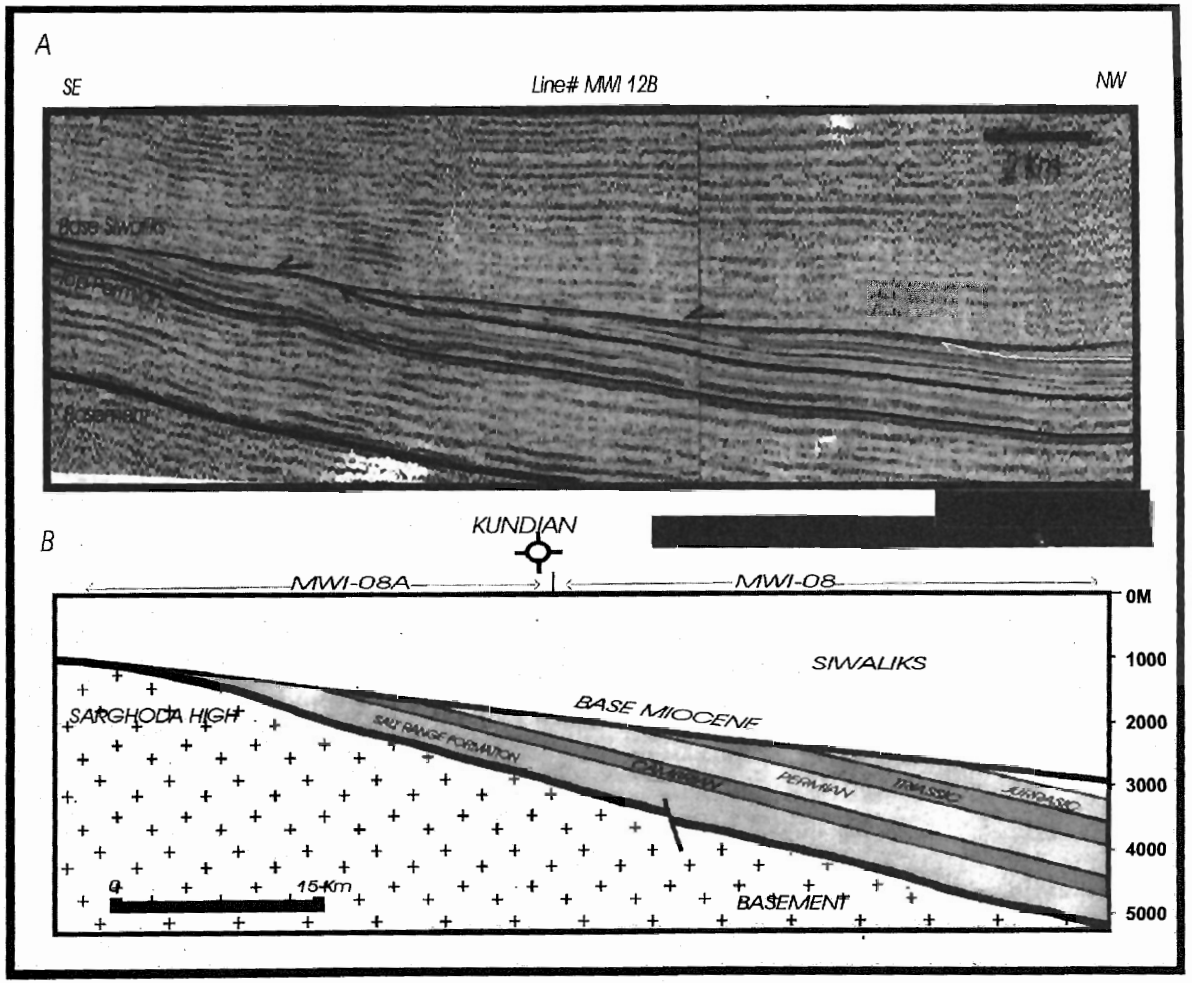

Fig. 3. Truncations of Mesozoic strata against Base Siwaliks and onlapping of Siwaliks on Unconformity. B. Section AB, GeoSeismic model on the northwestern part of Sargodha High which is based on interpretation of regional seismic lines.

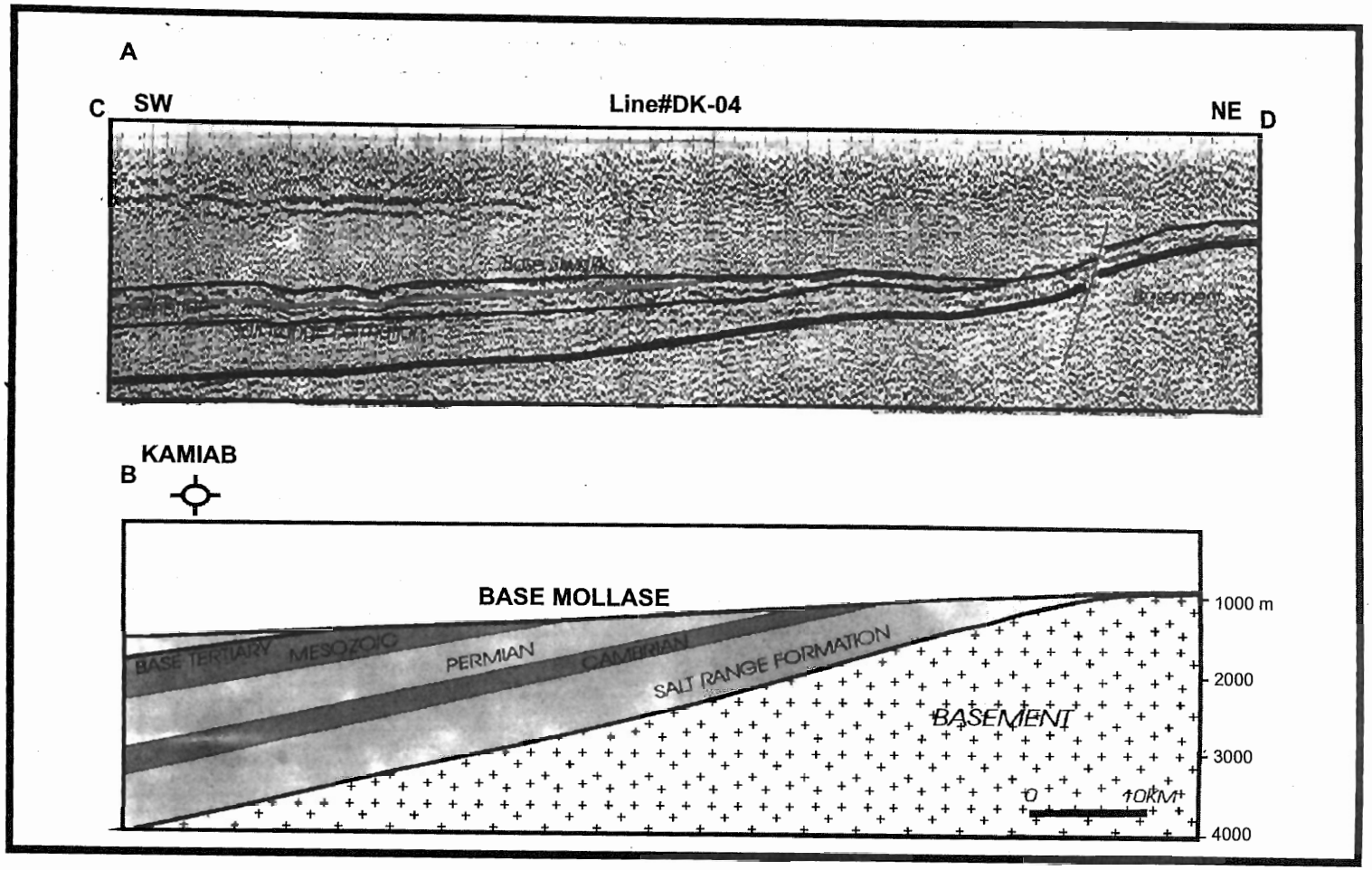

Fig. 4. A. Truncations of Cambrian strata against Base Siwaliks unconformity. B. Section CD, GeoSeismic model on southwest of Sargodha high.

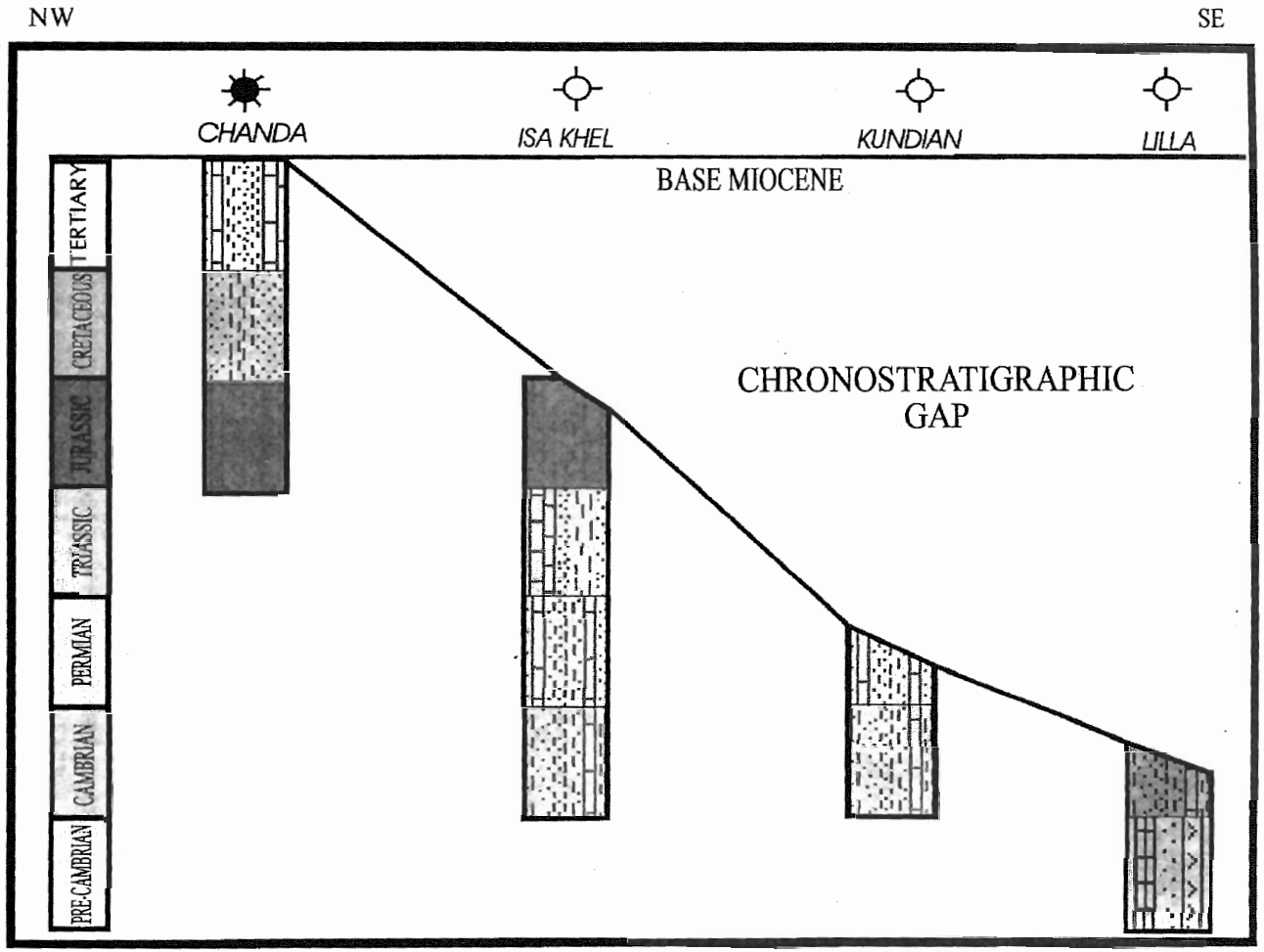

Fig. 5. Chronostratigraphic columns of wells in Himalyan foreland basin. Note the increase in the duration of stratigraphic gap towards forebulge (Sargodha high).

CONCLUSIONS

Sargodha High seems to be forebulge at the periphery of the Himalayan foreland basin. Base Miocene erosional unconformity in the upper Indus basin has the characteristics of a forebulge unconformity in the HFB. The geometry of the unconformity is characterized by maximum erosion away from the orogen and minimum towards orogen. Presence of such a forebulge unconformity allows the recognition of a possible truncation trap and seal configuration. In addition the long term exposure of the forebulge can enhance porosity below the unconformity.

REFERENCES

Coakely, B.J. & Watts, A.B., 1991. Tectonic controls on the development of unconformities: the north slope Alaska: Tectonic, 10(1), 101-130.

Crampton, S.L. & Allen, P.A., 1995. Recognition of fore bulge unconformities associated with early stage of foreland basin development: AAPG Bull. 79(10), 495-1514.

Sincair, H.D. & Allen, P.A., 1992. Verticle versus horizontal motiona in Alpine orogenic wedge: Stratigraphic response in the foreland basin. Basin Research, 4, 215-232.

Stockmal, Beamount, G. & Boutilier, R., 1986. Geodynamic models of convergent margin tectonic: Treansition from rifted margins to overthrust belt and consequence of foreland basin development. Am. Assoc. Petrol. Geologist., 70, 181-190.

Virdi, N.S., 1994. The floor of Tertiary basin of northwest India-controls of basement highs and Paleo topography on the basin evolution: Himalyan Geol., 15, 231-244.