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Structural Insights in the Proximity of Jhelum Fault Kashmir Basin, Sub Himalayas Pakistan

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ABSTRACT

This research has been carried out to know the structural style associated with the Hazara Kashmir Syntaxis in the vicinity of Doberan Kashmir region. The target area is the southern part of Hazara Kashmir Syntaxis (HKS) i.e., Sub-Himalayan region which lies in the proximity of Jhelum fault. The NW-SE trending fold-and-thrust belt of Himalayas marks abrupt bend to the NE-SW in the HKS (Hazara Kashmir Syntaxis). The Jhelum fault displaces the western extremity of Kashmir Syntaxis, which results the complex geological structures in Kashmir basin. Stratigraphically, the study area hosts the sedimentary rocks of Miocene to recent sediments, which are Kamlial Formation, Chinji Formation, Nagri Formation, Dhok Pathan, Soan Formation, Mirpur Formation, and alluvium. These rock units represent the molasse of Himalayan orogeny. Structurally, the research area is extensively deformed due to various tectonic episodes, like initiation of Hazara Kashmir Syntaxis, Jhelum fault, which formed the complex structures in term of folds and faults. The folds which have been observed in the field are Maliar anticline (A), Maliar syncline, Maliar anticline (B), Chouk Borjan syncline, Chouk Borjan anticline, Pajand syncline, Pajand anticline, and Sadiqabad syncline. Based on field observation nature of these folds is tight, isoclinal, close, open, and gentle. The prime faults observed in the studied domain are Jhelum Fault, Malikpur-Diljaba fault, Maliar fault and Chillayar fault. The Jehlum Fault is the main cause of deformational episodes, which runs through the center of the research area. The Malikpur-Diljaba fault is regarded as an intraformational fault which is marked within the Chinji Formation. The Malikpur-Diljaba fault and Maliar fault are the back thrust splay faults of the Jhelum Fault. Along the Chillayar fault Dhok Pathan rocks thrusted on the Nagri Formation strata. The tightly folded and imbricated block between the Malikpur-Diljaba fault and the Jhelum Fault is interpreted as a popup structure.

INTRODUCTION

Structural investigations in geology reveal the nature of geological structures and mark the deformational episodes of an area. The orientation and anatomy of small-scale features demarcate the nature and existence of regional structures exists in an area, from which the deformational history of various tectonic episodes were easily determined Price and Cosgrove (1990). During Eocene time Himalayan orogeny results the long chains of mountains system which comprises of the southward-propagating thrust masses in the form fold and thrust belts. The Pakistani Himalayan formed the hinterland portion in north whereas foreland portion to the south which comprises the regional thrust system like Main Karakoram Thrust/ Shyoke Suture zone, Main Mantle Thrust/Indus Suture zone, Main Boundary Thrust and Decolment Salt Range Thrust (SRT) (Kazmi and Rana 1982). The overall trend of the major structures exposed in the east west Himalayan Pakistan (Nakata and Kumhara, 2002). Hazara Kashmir Syntaxis is one of the notable geological structures of Hazara Kashmir region. Many workers like Lydekker (1883), Wadia (1928), Ashraf et al. (1983), Ashraf and Chaudhary (1984), Baig and Lawrence (1987), Meddlicott (1864, 1976), Munir and Baig (2006) discussed the geology of Kashmir area in very detail. The previously mentioned researchers recognized the regional geology and stratigraphy of the Kashmir along with its adjoining areas. Paleo-environments is also interpreted from the Paleogene sequence in the study area by Wells and Gingerich (1987). Moreover, the Geological Survey of Pakistan along with collaboration of Azad Jammu and Kashmir Mineral and Industrial Development Corporation mapped the area on a scale of 1:50,000 but no detail work has been carried out on the structure style of the area. The project area composed of the cover rocks of Indian plate which contains the molasses deposits of Himalayan (Akhtar et al., 2004). The research region exhibits the rocks of Rawalpindi Group and Siwalik Group. The Rawalpindi Group includes Kamlial while the Siwalik Group includes Chinji, Nagri,

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Dhok Pathan and Soan formations of Early Miocene-Pliocene age. The Pleistocene age Mirpur Formation is also present in Doberan and surrounding areas. The various exposed formations are recognized and differentiated through the mineralogical and lithological contents. The currents study deals with the first ever comprehensive geological and structural mapping of Dheri Qasim and Doberan area of Kashmir region that contribute to the new direction of structure style in the area. The key objectives of the present study are (i) to produce the geological and structural map of the study area on 1:50,000 scale, and to (ii) Draw and construct detail structural cross-sections as well as the π and β diagrams for the structural interpretation of the study area. The result of this research work will be very useful on its further consideration in the area for various purposes like seismic investigation and source rock potential evaluation as because of the similar subsurface geology is observed in the eastern bounded Potwar basin which is currently considered a good hydrocarbon producing basin in Pakistan. Furthermore, this data will be more useful as a field-based confirmation for remote sensing observation to know the structural style and active nature of these features.

STUDY AREA LOCATION

Research area is situated in southern part of (HKS) Hazara Kashmir Syntaxis which lies in the Sub-Himalayas of Pakistan (Figure 1). The bend of HKS is a prominent structure in Pakistan geological map which is formed through multiple stacks and thrust sheets. Two major i.e., higher Panjal and lower Murree thrust faults further subdivided the region into three tectonic zones including the tectonic components lies above the Panjal thrust, between the Panjal and Murree thrust, and the tectonic components lies below the Murree thrust (Bossart et al., 1988). Various lithological units are bringing together by these two thrust faults. The tectonic component lies above the Panjal thrust comprises of Tanol unit (Tanol Formation) of Marks and Ali (1961), Hazara Formation of Calkins et al. (1975) and Salkhala Series of Wadia (1928). The region between Panjal and Murree thrust is occupied by the Palaeozoic and Mesozoic rock sequences. While the tectonic region below the Murree thrust is characterize by the tertiary reddish to greenish sandstone and shale of Murree Formation (Bossart et al., 1988). The study area comprises of the Dheri Qasim, Bela Bhadarshah, Nala Musalmanan, Doberan and Khad areas of Azad Kashmir, Pakistan. The area lies between coordinate's 73°27/50//E to 73°41/50//E and 33°24/38//N to 33°27/31//N on topographic sheets numbers 43G /11 and 43G /7 of the Survey of Pakistan at 1:50,000 scale.

METHODOLOGY

The target areas for this research were surveyed in temperate weather with extreme care. Detailed field work was carried out to the selected spots of project area to mark the lithological contacts, measure dip and strike data. During the field, field photographs were captured through high resolution nikon digital camera. The area was mapped at 1:50000 scale. Strike direction was followed for the traversing along different formations. The various lithological contacts were mapped in the field and interpreted. The attitude of bedding was also recorded. The structural data were measured by the Brunton Compass. Field data were interpreted with the help of stereograms. The geological map and structural cross section were constructed in the ArcGIS software.

STRUCTURAL FEATURES OF RESEARCH AREA

The research area is the southern portion of HKS (Hazara Kashmir Syntaxis) lies in the proximity of Jhelum left lateral strike Fault. The HKS is a regional bend like structure shaped by folding of Himalayan thrust sheets in the form of antiform. These thrust sheets comprise the MBT (Main Boundary Thrust), PT (Panjal Thrust) and SRT (Salt Range Thrust) (Baig and Lawrence 1987). The Salt Range Thrust is displaced by Jhelum strike slip fault. Due to Himalayan orogeny Kashmir area is highly deformed and results a complex geological structure in the form of Folds (Figures 2, 3) and Faults (Figure 4).

Folds

The area is deformed due to a series of orogenic deformational episodes which results several compressional structures in the form of anticlines and synclines. The major folds structures exposed in research area are north-northeast and northwest to southwest trending (Figures 5, 6).

Maliar anticline (A)

This anticline is present in the Khad area of Kashmir which is formed by the bending of Kamlial Formation as shown in (Figure 2). This is an intraformational fold on surface exposure. Maliar fault is passes from the western limb of this anticline which displaces the strata. This anticline exhibits the N10°W/63°NE attitude on eastern limb, whereas N15°W/40°SW on the western limb. The eastward limb of Maliar anticline is gentler than the westward limb. The axial plane attitude is N12°W/80°SW whereas the plunge and trend of this anticline fold axis is 4°/169° (Figure 3a). The interlimb angle of the Maliar anticline is 77° (Table 1). On the base of the collected structural data, Maliar anticline (A) is categorized as a close fold with NE vergence.

Maliar anticline (B)

This fold is also formed within the Kamlial Formation and is regarded as intraformational fold as shown in (Figure 2). The eastern limb attitude of this anticline is N8°W/60°NE whereas the western limb attitude is N12°W/56°SW. The axial plane attitude is N10°W/88°SW along with the plunge and trend of the fold axis is 4°/170°. Interlimb angle of the Maliar anticline B is 64° (Table 2, Figure 3b). It has been classified that Maliar anticline B is a close NE vergent fold based on the collected field data.

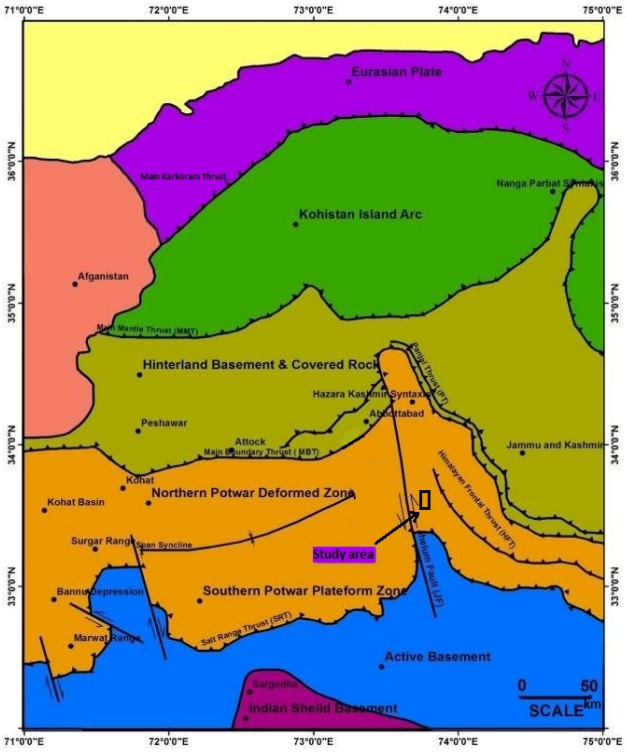

Figure 1 Geological Map of northern Pakistan with major features of the region (Modified after Wadia, 1928; 1931; Latif, 1970).

Table 1 Structural data of Maliar anticline (A)

Attitude of Bedding		Trend and Plunge of Fold Axis	Attitude of Axial Plane	Interlimb Angle	FoldType
Eastern Limb	Western Limb				
N10°W/63°NE	N15°W/40°SW	4°/169°	N12°W/80°SW	77°	Close

Table 2 Structural data of Maliar anticline (B)

Attitude of Bedding		Trend and Plunge of Fold Axis	Attitude of Axial Plane	Interlimb Angle	FoldType
Eastern Limb	Western Limb				
N8°W/60°NE	N12°W/56°SW	4°/170°	N10°W/88°SW	64°	Close

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Table 3 Structural data of Maliar Syncline

Attitude of Bedding		Trend and Plunge of Fold Axis	Attitude ofAxial Plane	Interlimb Angle	FoldType
Eastern Limb	Western Limb				
N12°W/56°SW	N10°W/40°NE	1°/169°	N11°W/82°NE	84°	Close

Maliar syncline

Maliar syncline is exposed in the outcrop of Kamlial Formation, which is formed by the bending of same strata of Kamlial Formation and is regarded as an intraformational fold (Figure 2). Attitude of the

eastern limb of this syncline is N12°W/56° SW along with the attitude of western limb is N10°W/40°NE. The axial plane attitude of this syncline is N11°W/82°NE while the plunge and trend of this synclinal structure is 1°/169° (Figure 3c, Table 3) along with the 84° interlimb. Maliar syncline is regarded is close SW vergence fold on the base of the field data.

Chouk Borjan anticline

This anticline structure is formed by the bending of Miocene strata. Murree Formation lies in core of this structure whereas Kamlial Formation is exposed on the limbs of this anticlinal feature. Based on field data it has been regarded as overturned isoclinal anticlinal fold (Figures 5, 6)

Sadiqabad syncline

The bending of Dhok Pathan Formation results the Sadiqabad Syncline. In this structure Dhok Pathan Formation cover the core of syncline while the Nagri formation is exposed along the limbs. Based on The filed data and interlimb angle this syncline is gentle in nature with SW vergence (Figures 5, 6)

Faults

Due to initiation of Hazara Kashmir Syntaxis a series of thrust faults develop in the study area. These faults include Chillayar fault, Malikpur-Diljaba fault, Maliar fault, Jhelum Fault (Figure 4).

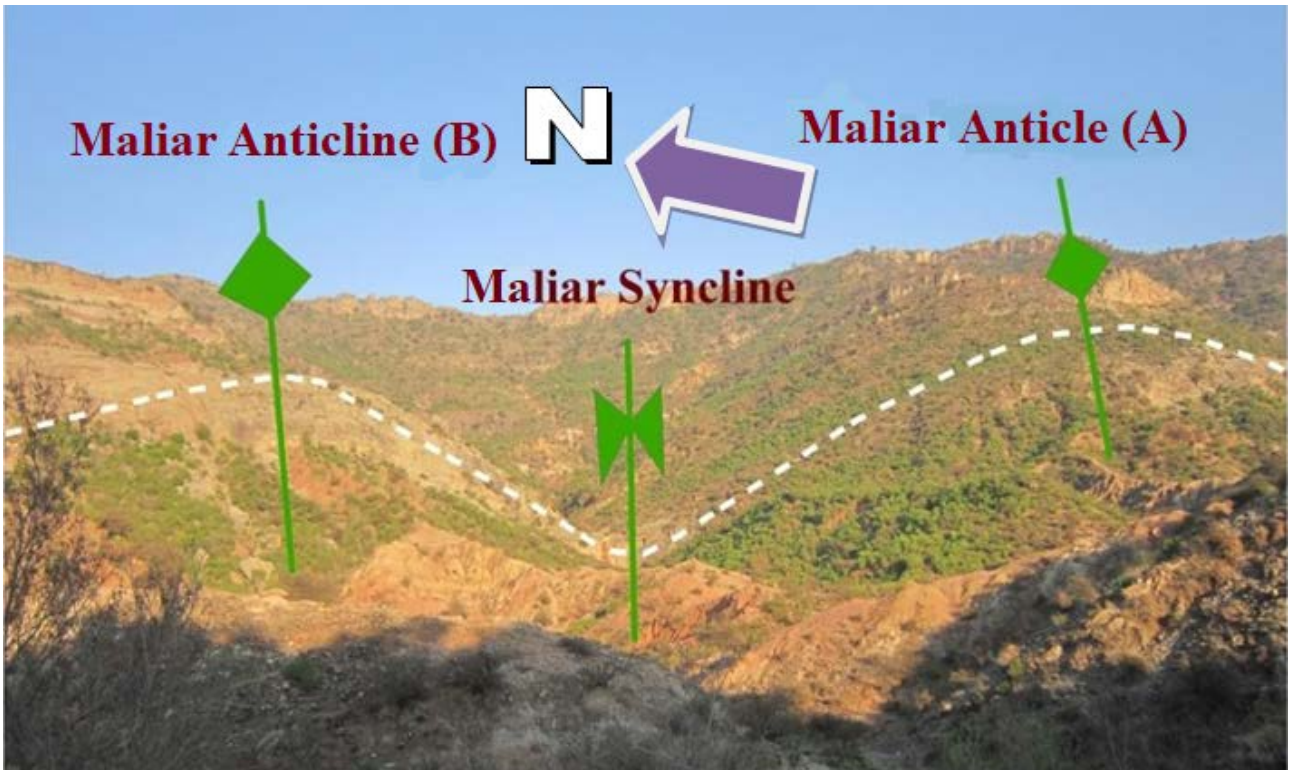

Figure 2 Showing the Maliar Anticline A and B along with Maliar Syncline.

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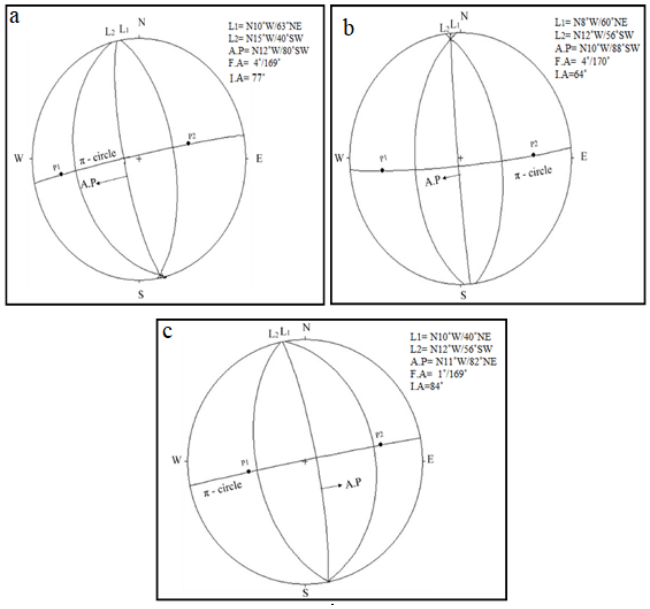

Figure 3 -(a) π & β diagram of Maliar anticline (A). (b) π & β diagram of Maliar anticline (B). (c) The π & β diagram of Maliar syncline

Chillayar fault

Chillayar fault is one of the prominent geological features and is regarded as a reverse fault with NW-SE trend. Along this fault the early Pliocene Nagri Formation is thrusted over the middle age Pliocene Dhok Pathan Formation (Cross-sections AA' Figure 6). In the research area, this fault is shortened by Jhelum strike slip Fault nearby Banhil region. Hanging wall block attitude is N31°W/20°SW whereas foot wall block attitude is N39°W/24°NE. Fault plane attitude of this fault in the study area is N40°W/50°SW. The disturbed and deform strata along the fault is shown in (Figure 4a). From the field data it has been regarded as back thrust of research area b.

Malikpur-Diljaba fault

The Malikpur-Diljaba fault is regarded as reverse fault which is exposed with in Chinji Formation (Figures 4b, 6). The lower Chinji Formation has been thrusted on the upper Chinji Formation. The fault plane attitude of this fault is N30°E/65°SE. Based on shearing and crushing of rocks this fault has been identified in the field (Figure 4b). In north it runs between Chinji Formation and Soan Formation near Dhok Sudran. In Khad section, this fault is marked by the Chinji Formation on the hanging wall whereas Soan Formation is present on the footwall block (Figure 4b). It is regarded as second major fault of research area after Jhelum Fault which runs northeast southwest. The Malikpur-Diljaba fault is regarded as a back thrust also known as splay of Jhelum Fault.

Maliar fault

This fault is also known as splay branch of Malikpur-Diljaba fault and is regarded as reverse fault in nature. Along the Maliar fault, Middle to late Miocene Kamlial Formation is thrusted over the Soan Formation of Pliocene age (Figure 4c) at Maliar section (Figure 6).

Jhelum fault

Jhelum Fault is a regional fault of Kashmir region which runs throughout research area. This fault is recognized as NE-SW trends and NW dipping high angle fault. The attitude of fault plane in Banhil section is N70°E/63°NW. The Dhok Pathan Formation shows an attitude of N42° W/39°NE whereas attitude of Kamlial Formation is N60°E/55°SE in the field. Based on field observation it has been regarded as a left lateral strike slip (LLSS) fault with a reverse motion. The Jhelum Fault (Figure 6) is passes under the alluvium in Banhil area. In the study area, the Jhelum Fault is traced to be runs between the Kamlial Formation and Dhok Pathan Formation. Near the Pajand area, the Kamlial Formation is thrusted over the Dhok Pathan Formation (Figure 4d). This Fault sharply truncates the fold and thrust belt along the western and eastern flanks of Jhelum River near Pajand area.

DISCUSSIONS

The Hazara Kashmir Syntaxis is a regional antiformal like structure which is formed by the folding of Panjal Thrust and Main Boundary Thrust. Hazara Kashmir Syntaxis is marked as a tight antiform in the north and is opens towards the south. The core of this Syntaxis highly deformed and the western limb of HKS (Hazara Kashmir Syntaxis) is displaced by Jhelum strike slip Fault (Bossart et al., 1988). Lithologically, research area comprises of the Miocene and post Miocene rocks which includes Kamlial Formation, Chinji Formation, and Nagri Formation, Dhok Pathan Formation, Soan Formation, Mirpur Formation and Recent alluvium. These rock units are also regarded as molasses of the Himalayan orogeny. This molasses sequence is highly deformed due to tectonic episodes of Hazara Kashmir Syntaxis which resulted complex geological structure in term of folds and faults. Geological structures in the form of folding are common in area because of the soft lithologies. The major folds observed in the field are Maliar anticline (A), Maliar syncline. Maliar anticline (B), Chouk Borjan syncline, Chouk Borjan anticline, and Sadiqabad syncline. In the Maliar section, Maliar anticlines and synclines are formed due to the folding of Kamlial and Murree Formation. The Murree Formation occupies the core while the Kamlial Formation

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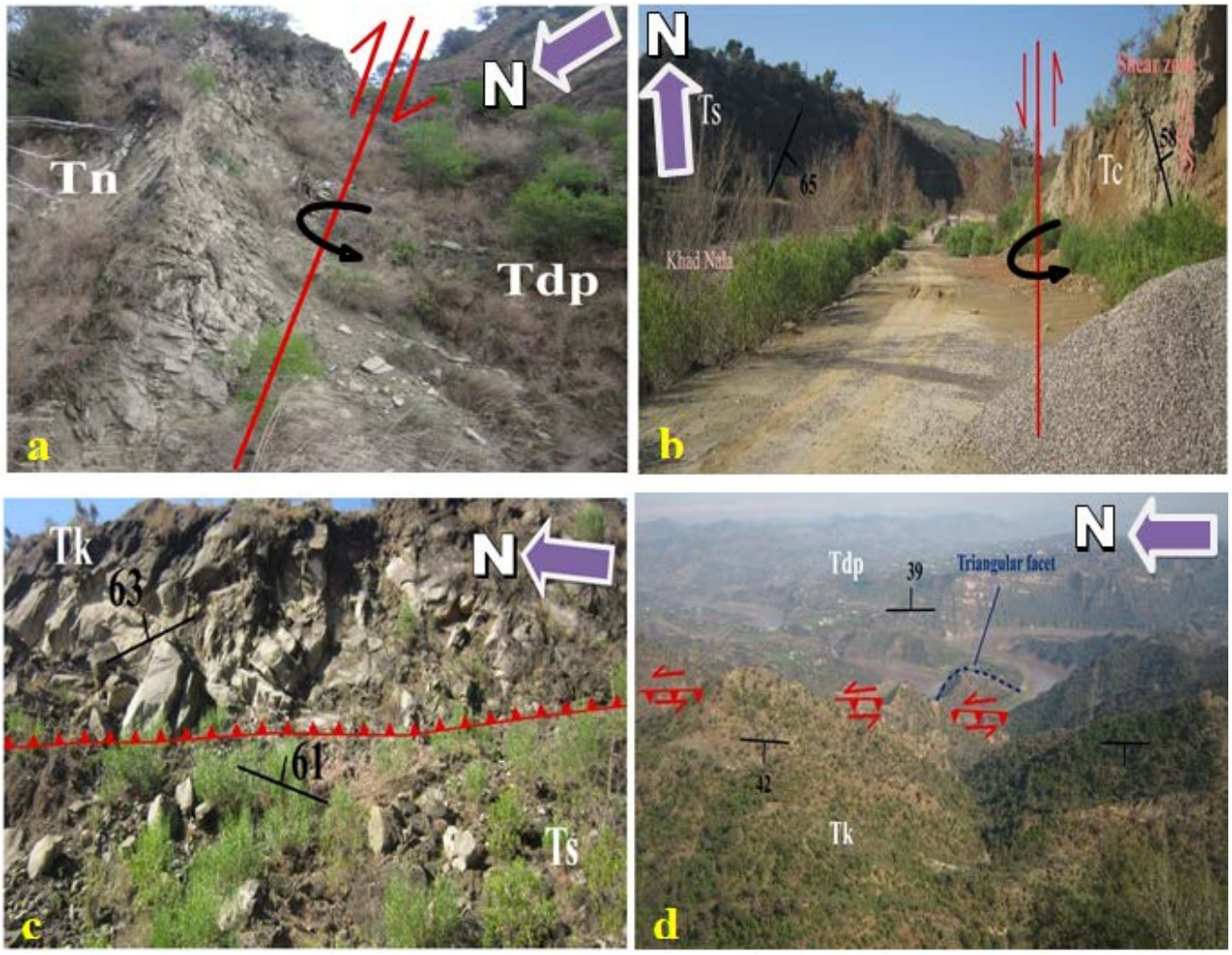

Figure 4 -(a) Nagri Formation (Tn) and (Tdp) Dhok Pathan Formation along Chillayar fault. (b) Malikpur-Diljaba fault showing Tc (Chinji Formation) against Ts (Soan Formation) in Khad area. (c) Tk (Kamlial Formation) and Ts (Soan Formation) along Maliar fault in Maliar section. (d) Surface exposure of Jhelum Fault in between the Tdp (Dhok Pathan Formation) and Tk (Kamlial Formation)

lies on the limbs of Maliar anticlines whereas Kamlial Formation is traced along the core of Maliar syncline. These folds are characterized by its asymmetric and close nature which exists in between the Malikpur-Diljaba and Maliar faults. Their fold axes are truncated by the Malikpur-Diljaba fault. The north-south trending and west vergent overturned Chouk Borjan syncline, Chouk Borjan anticline occurs in between the Jhelum Fault and Malikpur-Diljaba fault. The Malikpur-Diljaba fault is back thrust splay fault of Jhelum Fault. The folded and imbricated hanging wall block between these faults is interpreted and regarded as popup structure. The Sadiqabad syncline is resulted due to the bending of Dhok Pathan Formation. Dhok Pathan Formation is in the core of syncline whereas the Nagri Formation exists on the limbs of the Sadiqabad syncline. Based on interlimb angle, this synclinal structure is regarded as gentle fold. Besides from folds structures, the prominent existing faults in the research area include the Chillayar fault, Malikpur-Diljaba fault and Maliar fault and Jhelum Fault. Chillayar fault is a reverse nature fault where the Nagri Formation occupies the hanging wall whereas the Dhok Pathan Formation lies on the footwall of the fault. The Malikpur-Diljaba fault is also reverse nature fault. In the south of research area, lower Chinji Formation has been thrusted over the upper Chinji Formation whereas in north it runs between Chinji Formation and Soan Formation. In Khad area Chinji Formation lie on the hanging wall and the Soan Formation on the footwall. Maliar fault is a reverse splay of Malikpur-Diljaba fault. This fault passes in between Kamlial Formation and Soan Formation. Kamlial Formation lies on the hanging wall block and Soan

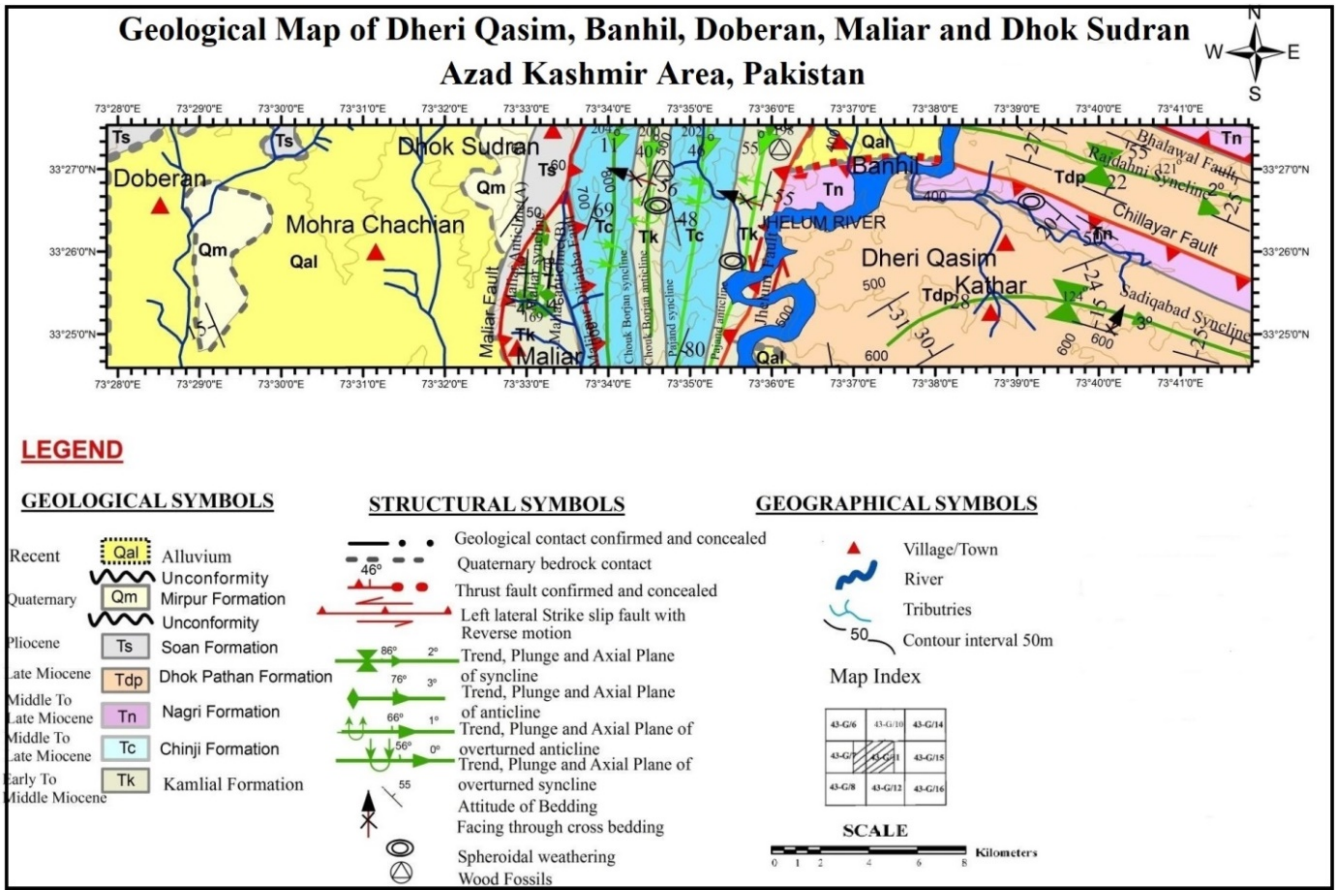

Figure 5 Structural map of Study Area

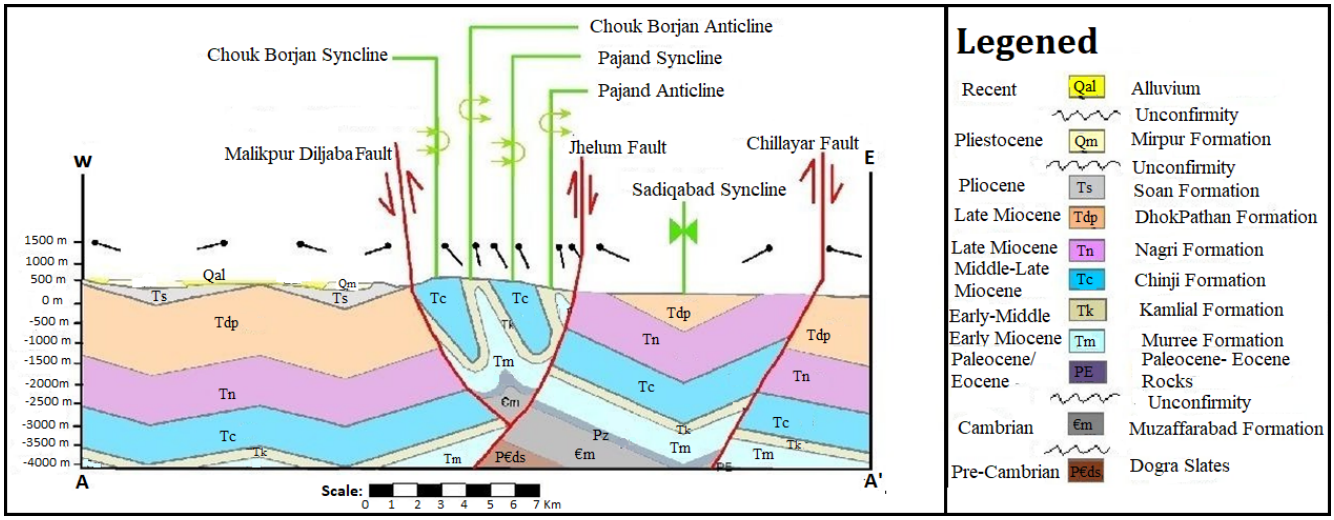

Figure 6 Cross Section map of Study area

Formation lies on the footwall. Jhelum fault is a regional strike slip fault running through the research area. It is northeast-southwest trending and northwest dipping high angle fault as well as a LLSS (left lateral strike slip) fault movement. In the research area, this fault runs in between Dhok Pathan Formation and Kamlial Formation. Jhelum Fault sharply truncates the fold and thrust belt in the western and eastern flanks of Jhelum River near Pajand area.

CONCLUSION

From the current detailed mapping it has been concluded that the study area encompasses the complex geological terrains which endured from various tectonic

episodes and resulted the compressional geological features. First phase of deformation is associated with the Himalayan orogeny and second phase is associated with the formation of Hazara Kashmir Syntaxis which intensely deformed the area. Furthermore, the initiation of Jhelum fault also plays a key role in the deformation of and experiences the phase wise deformation which results the highly deformed folds and faults in the Kashmir region. The folds observed and studied in the project area are isoclinal, tight, close, open, and gentle in nature. The vergence of these folds studied in project area is NW, NE and SW. Jhelum fault is the major strike slip fault which passes from the research area along with its splays in the form of back thrusts. It has been confirmed from the current research that Jhelum fault is the major cause of deformation in research area. The tightly folded strata and imbricated block in between the Malikpur-Diljaba fault and the Jhelum Fault is interpreted as popup structure.

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