Geol. Bull. Univ. Peshawar, 1989, Vol. 22, pp. 45-54

STRATIGRAPHY AND STRUCTURAL EVENTS AROUND THE SOUTHERN MARGIN OF PESHAWAR BASIN, PAKISTAN

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ABSTRACT

The Peshawar intermontane basin is superimposed on the fold-thrust belt at the southern margin of the Pakistan Himalayas. In the southern part of the basin the first Ordovician rocks were identified near Nowshera on the basis of discovery of trilobite trace fossils and consequently the Paleozoic stratigraphy of the area has been revised and modified. The Attock-Cherat Range forms the southern boundary of the Peshawar basin and includes rocks transitional between metasediments of Lesser Himalaya and foreland basin strata of Kala Chitta Range to the south. The range is dominated by slate, less metamorphosed argillaceous and arenaceous strata and subordinate limestone of Precambrian to Paleozoic age. These rocks are unconformably overlain by a thin cover of Jurassic, Cretaceous?, Paleocene, Eocene and Miocene rocks. The structural events close to the Peshawar basin are recognized in pre-Paleocene, pre-Pliocene and late Quaternary times. The Peshawar basin formed as the Kala Chitta Range was faulted south on the Main Boundary Thrust (MBT) pushing the Siwalik foreland basin still further south. Evidence for active tectonics is found in four left-stepping en-echelon pressure ridges formed within Peshawar basin parallel to its southern margin.

INTRODUCTION

The sediments of Peshawar basin include lacustrine, deltaic, fluvial, alluvial, flood plain and loess deposits. The deposition began 2.8 Ma when the southward-verging folding and thrusting in the Attock-Cherat Range ended (Burbank and Tahirkheli, 1985). During the time of deposition of Peshawar basin, sedimentation continued in the Siwalik foredeep basin to the south in Surghar Range and Trans-Indus Salt Range and to the southeast in Potwar Plateau (Raynolds and Johnson, 1985). The sediments of Peshawar basin are tilted, folded and faulted along ENE trending faults with north side upthrown (Figs. 1 to 4).

The stratigraphic sequence previously established by Stauffer (1989) near Nowshera in the southern Peshawar baisn has been revised and modified, based on the recent geological investigations of the area (Pogue and Hussain, 1986). The discovery of *Cruziana* ichnofossils of Early Ordovician age have established that the rock sequence near Nowshera is not only of Silurian-Devonian age but is also of Ordovician and possibly Cambrian age.

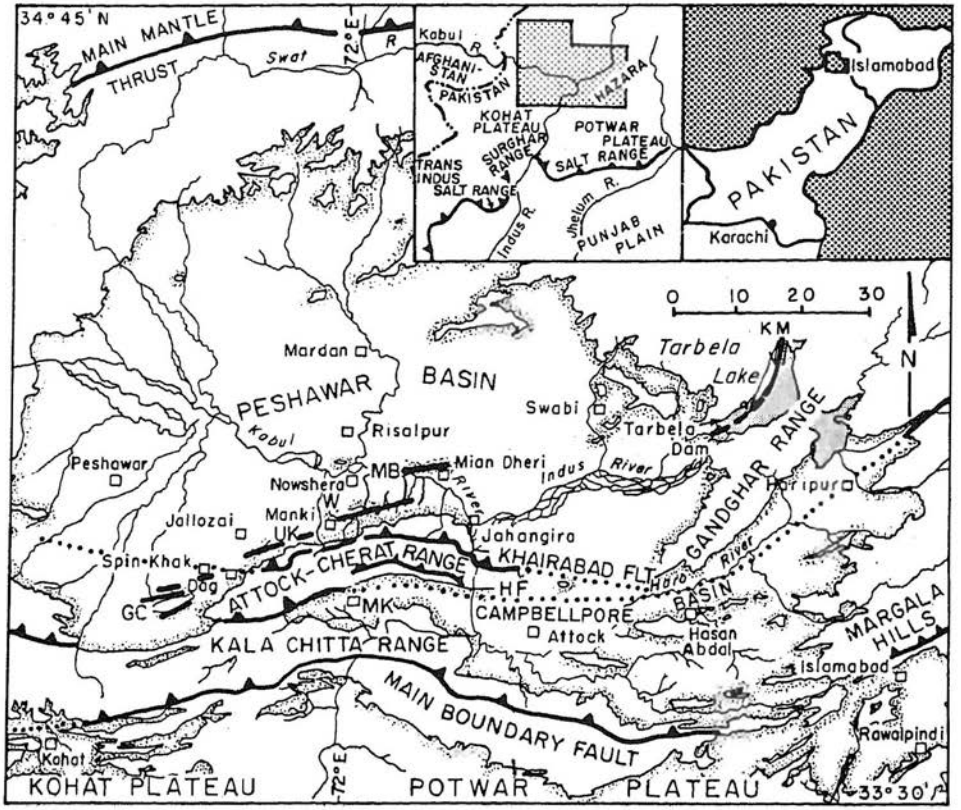

Fig.1. General geology of the Peshawar Basin and its adjoining areas.

South of Peshawar basin, the Attock-Cherat Range comprises three east-west trending blocks that are bounded by thrust faults. From north to south these consist of (1) argillite, slate, phyllite and limestone of Precambrian age intruded by dolerite sills and dykes, (2) siltstone, argillite, quartzite and subordinate limestone of Precambrian age overlain by Jurassic, Cretaceous?, Paleocene, Eocene and Miocene rocks, (3) unfossiliferous limestone, dolomite, argillite and quartzite overlain by Tertiary sequence similar to that in block 2. Farther to the south the Attock-Cherat Range is thrust over the folded strata of Kala Chitta Range. Some nomenclature of rock units of the Precambrian and the Paleozoic sequence proposed in the present study are adopted after Stauffer (1968) and Tahirkheli (1970).

PREVIOUS WORK

The first geological account of the area was given by Wynne (1873) who considered the rocks of Nowshera and Cherat Range to be Paleozoic on the basis of similarity of the rocks with Hazara. Other early workers included Griesbach (1892), Waagen (1884), Middlemiss (1896), Wadia (1930) and Cotter (1933). Teichert and Stauffer (1965) made the first discovery of Silurian-Devonian fossils near the town of Nowshera. The area was later described by Barnett and others (1966), Stauffer (1968), Ali and Anwar (1969), and Latif (1970). Tahirkheli (1970) conducted detailed geological study of the Attock-Cherat Range and differentiated the

rocks into thirteen mappable units. The stratigraphic sections in the westernmost part of the area were described by Meissner and others (1974). Pliocene and Pleistocene sediments were described by Burbank (1983) and Burbank and Tahirkheli (1985). Hussain (1984) prepared a regional geological map of Nizampur covering part of Peshawar, Mardan and Attock districts, and Pogue and Hussain (1986) revised the stratigraphy of Nowshera area based on the discovery of trilobite trace fossils. Yeats and Hussain (1987) worked out the timing of Structural events in the Himalayan foot hills.

STRATIGRAPHY

The rocks exposed around the southern margin of Peshawar basin in Nowshera and Attock-Cherat Range are dominated by metasediments of lesser Himalaya of Precambrian to Devonian age. These rocks are overlain by Kala Chitta foreland basin strata of Jurassic to Early Miocene age. The Attock-Cherat Range consists of three structural blocks that are bounded by thrust faults.

The northern block consists predominantly of Manki Formation, mainly dark grey to black slate and phyllite with subordinate lenses of yellowish grey limestone and quartzite. The formation resembles the Hazara Formation to which Crawford and Davies (1975) and Calkins et al. (1975) have assigned Precambrian age. The Manki Formation is conformably overlain by Shahkot Formation which consists of light brownish grey limestone and interbedded dark, greenish grey phyllite. Limestone near the top of the formation south of Utch Khattak village yielded fossils tentatively indentified as bryozoans of lower Paleozoic age (Tahirkheli, 1970). The overlying Utch Khattak Formation comprises predominantly rubbly and stromatolitic limestone with grey to buff argillaceous laminations. Near Khairabad, at Raja Hodi railway tunnel, the Utch Khattak Formation contains clasts of Shahkot and Manki formations and therefore younger than both. The Shekhai Formation is the youngest sequence of the northern block and represented by medium to thick bedded and massive limestone with subordiante quartzite. The limestone is brecciated in the middle and upper parts. The lithological similarity of Manki Formation with Precambrian Hazara slate and normal, locally graditional, contacts within the different rock units of the block suggest that all the formations are of Precambrian age. Dolerite dykes and sills are commonly found in this block.

The central block is principally underlain by Dakhner Formation which consists of a thick sequence of siltstone, argillite, quartzite and subordinate limestone. Tahirkheli (1970) considered the age of this sequence to be middle Jurassic-Cretaceous on the basis of fossils in the limestone that he considered to be interbedded within the formation. All the fossils found during our study including Tahirkheli's locality, are in Cenomanian or Paleocene limestone that overlies the Dakhner unconformably or in thrust contact with the Dakhner. At Hasan Abdal, east of Attock-Cherat Range, the Jurassic limestone lies unconformably on Dakhner Formation. The formation has been tentatively assigned Precambrian age on the basis of lithological correlation with the Hazara Formation for which Rb/Sr dates of 740 ± 20 and 930 ± 20 M.a. have been reported (Crawford and Davies, 1975). Unlike the northern block, the central block contains no instrusion of dolerite (Tahirkheli, 1970) except for one occurrence in limestone east of Indus River. The Dakhner Formation is unconformably overlain by a thin cover of Jurassic, Cretaceous, Paleogene and Miocene rocks.

The southern block consists of a north dipping homoclinal sequence that is right side

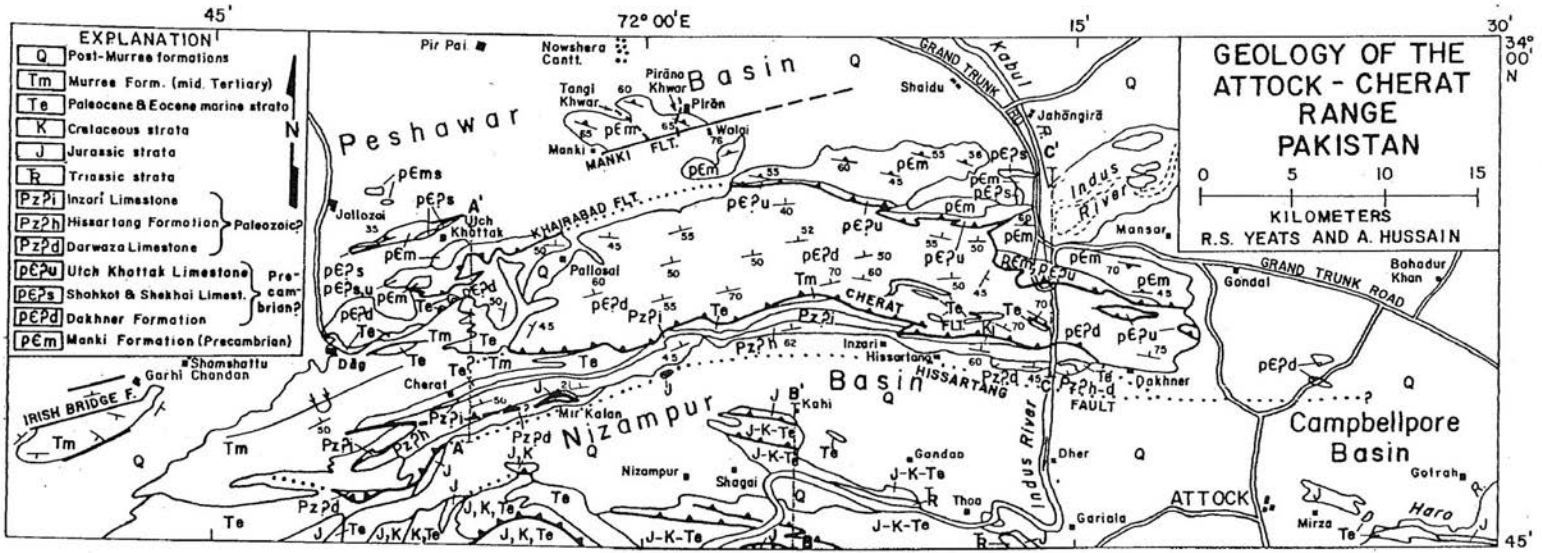

Fig. 2: Geology of the Attock-Cherat Range, Pakistan

up. The Darwaza Formation is the oldest unit and is represented by limestone and dolomite that grades upward into grey-green and maroon shale. The Hisartang Formation consists of dark grey to black argillite and light grey quartzite that display impressions of worm burrows. The overlying Inzari limestone is yellowish and contains black lamination on weathered surfaces. Despite a prolong search and repeated sampling for conodonts, no fossils have been found in the Darwaza, Hisartang and Inzari sequences. However, certain lithologies, particularly the maroon shale of the upper Darwaza and worm burrow impressions in the quartzite of Hisartang, suggest a correlation with the Paleozoic rocks of the Nowshera area.

The stratigraphic sequence of the Nowshera area, as established by Stauffer (1968), has been modified and revised on the basis of detailed geological mapping and supported by faunal evidence. The oldest rocks cropping out along Kabul River near Misri Banda and Mian Dheri villages belong to Ambar Dolomite. The upper part of the Ambar Dolomite is more massive and displays stromatolitic laminations. The contact of the Ambar Dolomite with the overlying Misri Banda Quartzite is marked by a 5-10 metres of argillite with interbedded dolomite and quartzite. The Misri Banda Quartzite is light grey, medium to thick bedded and displays conspicuous cross-bedding and worm burrows. The interbedded quartzite and argillite in the upper Misri Banda near Mian Dheri has yielded the trilobite trace fossil *Cruziana rugosa d'Orbigny* of Lower-Middle Ordovician age. The unconformable contact of the Misri Banda Quartzite with the Panjpir Formation is marked locally by a conglomerate of sub-angular cobbles and boulders of Ambar Dolomite and rounded pebbles and cobbles of Misri Banda Quartzite in calcareous quartzite matrix. The Panjpir formation consists of interbedded argillite and limestone that have yielded upper Silurian conodonts. The Panjpir Formation is overlain by the massive light grey to pink marbles and calcareous quartzite of Nowshera Formation. The marble exposed in the Risalpur area displays the rich fauna characteristc of reef environment (Stauffer, 1968). The fossiliferous beds near Risalpur and Pir Sabak have yielded Lower Devonian conodonts (Barnett et al., 1966).

STRUCTURAL EVENTS

The structure of the area is well preserved to the south of Peshawar basin in the Attock-Cherat Range which is comprised of three east-west trending thrust-bounded blocks that dip generally north. The metamorphosed Paleozoic? sequence of the range is faulted against the unmetamorphosed Mesozoic and Early Cenozoic strata of Kala Chitta Range. The contact between the Paleozoic rocks of Nowshera and the Precambrian rocks of Attock-Cherat Range is concealed under Quaternary cover. The area is folded into several anticlines and synclines that are generally verging towards south. Three major faults named as Khairabad thrust, Cherat thrust and Hisartang thrust dominate the structural style of the area. In addition, a number of reverse, thrust and strike slip faults of smaller magnitude are found in the area. Evidence of active tectonics is also found at the southern margin of Peshawar basin (Fig. 2).

Pre-Paleocene Deformation

The similarity of the Tertiary sequence in the Kala Chitta Range and the central and southern blocks of the Attock-Cherat Range demonstrates that the pre-Lockhart sequence was juxtaposed by Hisartange and Cherat faults prior to the deposition of Paleocene Lockhart Limestone, and the contrast between the older rocks argues for larger pre-Paleocene displacement. The pre-Lockhart age of the Khairabad fault is less clear because Tertiary strata are not

TABLE 1. THE STRATIGRAPHIC SUCCESSION IN THE ATTOCK-SHEART RANGE AND NOWSHERA AREA.

Age	Southern Block	Attock Cherat Range Central Block	Northern Block	Nowshera Hills
Recent to Pliocene	–	–	–	Basin fill deposits
Early Miocene	Murree Fm.	Murree Fm.	–	–
Early Eocene to Late Paleocene	Patala Fm.	Patala Fm.	–	–
Paleocene	Lockhart L.St.	Lockhart L.St.	–	–
Early Palaeocene	Hangu Fm.	Hangu Fm.	–	–
— — — — — — — — — — — —		Unconformity	— — — — — — — — — — — —	
Late Cretaceous	–	Unnamed Limestone		
Early Devonian	Inzari L.St.	–	–	Nowshera Fm.
to	Hisartang Fm.	–	–	Panjpir Fm.
Cambrian?	Darwaza Fm.	–	–	.... Unconformity ....
				Misri Banda Qtzite
				Ambar Dolomite
Precambrian?	–	Dakhner Fm.	–	–
	–	–	Shekhai Fm.	–
	–	–	Utch Khattak Fm.	–
			Shahkot Fm.	–
			Manki Fm.	–

Note:- Precambrian to Early Devonian rocks are intruded by dolerite dykes and sills.

preserved north of this fault. The pre-Lockhart thrusting may coincide with the collison of India against Eurasia (Yeats and Hussain, 1987).

The Hisartang and Cherat faults continue as major tectonic features up to the western end of the Attock-Cherat Range (Fig. 2). Farther west the Hisartang fault continues within the Lockhart and the Cherat fault disappears westward in Murree Formation of early Miocene age. This also indicates that most of the displacement on these faults juxtaposing contrasting pre-Lockhart sequence is pre-Tertiary.

In Kala Chitta Range, the Lockhart limestone overlies the upper Cretaceous Kawagarh Formation, but close to the Hisartang fault at the western end of the Nizampur basin (Fig.2), the Lockhart Limestone rests on Jurassic. This suggests a south dip of Mesozoic strata of Kala Chitta Range near the Hisartang fault prior to Lockhart deposition.

Pre-Pliocene Deformation

The pre-Pliocene folding and thrusting involving Murree Formation of lower Miocene age took place prior to the depositon of the Peshawar intermontane basin fill of Pliocene-Pleistocene age. The post-Miocene displacement on Hisartang and Cherat faults is small as compared to the pre-Lockhart displacement. This is well documented by the presence of similar Tertiary strata over the central and southern blocks of Attock-Cherat Range. In western end of

the range, near Cherat Cement Plant, an overturned sequence of Shekhai Limestone and Utch Khattak Limestone is thrust over Patala, Lockhart and Dakhner formations along the Khairabad fault which is strongly folded into anticlines and synclines.

The Dakhner Formation in the central block dips homoclinally to the north in all parts of the range except the western end, where it dips west, down plunge. The unconformable contact with Tertiary strata has been sheared locally into decollement and in at least two places, west and south of Pallosai (Fig. 2), the contact has been displaced by faults down thrown to the south.

The southern block bahaved rather simply in post-Murree time except for the development of bedding thrust and ramp northwest of Qamar Mela (Fig. 2). This fault repeats the Inzari Limestone, Patala Formation and part of the Murree Formation. Renewed movement on Hisartang fault brought Darwaza Limestone over Lockhart Limestone, but this displacement is small compared to the pre-Lockhart displacement juxtoposing Darwaza Limestone and Jurassic strata. West of the Darwaza exposure, the Hisartang fault is entirely within Tertiary strata, and separation is small. The post-Murree tectonic events correlate with the time of major movement on the Main Central Thrust (MCT) of India and Nepal and also with the Precambrian crystalline rocks thrust over the lesser Himalayan sequence (Yeats and Hussain, 1987).

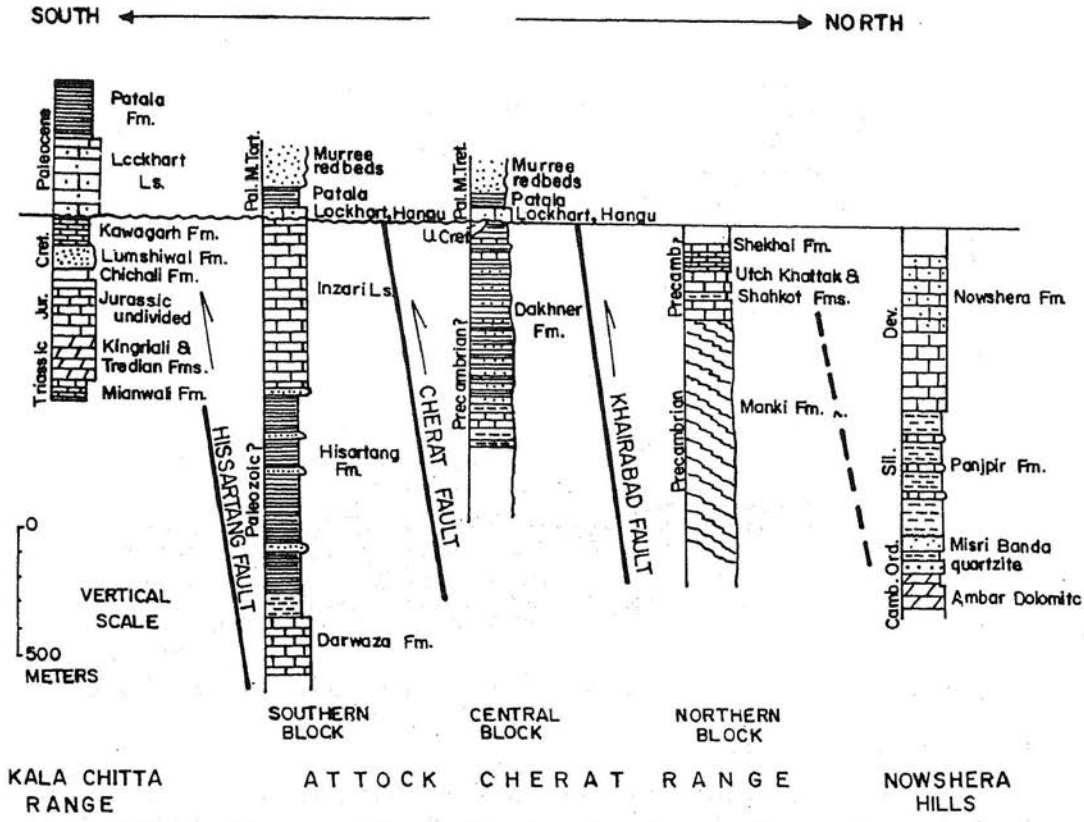

Fig. 3: Stratigraphic sequence in Nowshera Hills, Attock-Cherat Range and Kala Chitta Range, Pakistan.

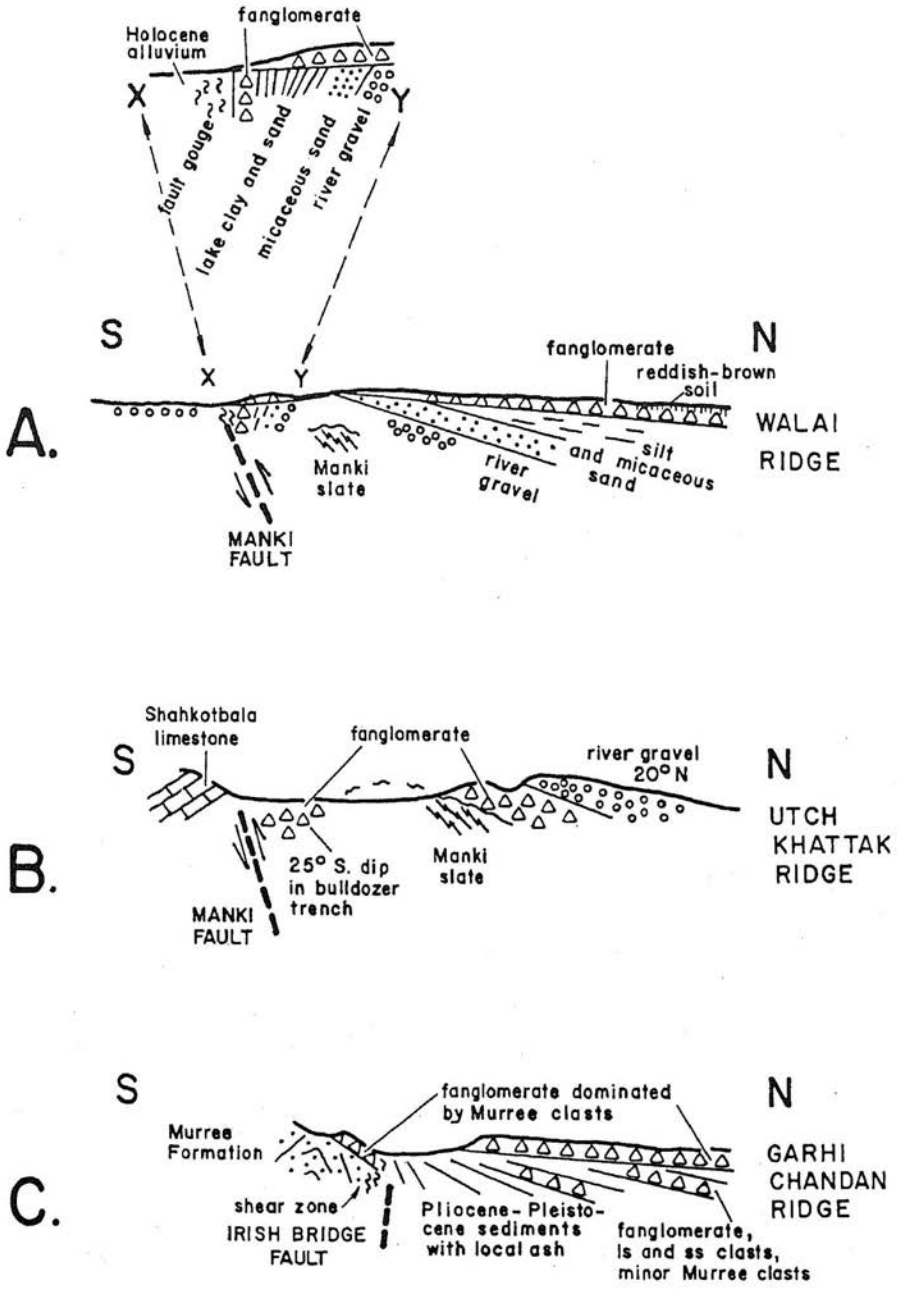

Fig. 4: Digrammatic Cross Sections of three Pressure Ridges North of the Attock-Cherat Range, Pakistan.

Late Quaternary Deformation:

The deposition of Peshawar basin fill including the lacustrine deposits continued from 2.8 to 0.6 Ma (Burbank and Tahirkheli, 1985). After the termination of deposition, four en

echelon, left-stepping pressure ridges formed within the Peshawar basin close to and parallel to the front of Attock-Cherat Range to the south. The pressure ridges are, from west to east, Garhi Chandan ridge, Utch Khattak ridge, Walai ridge and Misri Banda ridge, each named after the villages located in the vicinity. Lacustrine, fluvial and alluvial fan deposits dated 2.8 to 0.6 Ma are strongly folded, faulted and eroded prior to deposition of the recent alluvial fan gravel which are themselves cut by ENE-trending faults. All documented faults have north side up, and appear to cut Holocene deposits at places (Fig. 4).

Local steep dips in the Quaternary sediments adjacent to ridge front faults indicate that part of the deformation was by folding. The straight trace of some of the faults in contrast to the lobate trace of late Quaternary thrust at the foot of Salt Range suggests that these faults are relatively high angle involving the basement. The left stepping pattern of these suggests that they were formed by oblique-slip faulting with component of left-lateral strike slip and reverse slip. The deformation zone may continue east to Tarbela Dam, where similar deposits are folded and faulted, and a fault appears to displace the base of Indus River gravel at the dam. The zone may extend south across the Attock-Cherat Range where bed rock is faulted against Nizampur basin fan gravel and ENE-trending photo lineation in Attock-Cherat Range may represent additional north-side-up faults discordant to older thrust structure.

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