GEOLGY OF A PART OF ATTOCK-CHERAT AND KALACHITTA RANGES IN THE VICINITY OF NIZAMPUR, N.W.F.P., PAKISTAN

A thesis presented for the degree of Master of Philosophy at the University of Peshawar.

M. KHALID PERVEZ, NCE in Geology, University of Peshawar, August, 1982.
The project reported in this thesis was started in March, 1986. No portion of this work has been submitted in support of an application for another degree or qualifications at this or any other University.
In the Name of ALLAH

"Knowledge & Research:
thought man what he know not"

(AL-QURAN)
Dedicated to my loving parents.
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last but not the least, I am really indebted to the patience of my family during all this work.
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Abstract

Rocks of the Attock-Cherat and Kalachitta Ranges are thoroughly mapped and studied to work-out their structural patterns. The two Ranges are separated by a well defined Hissartang Thrust.

The rocks of the Attock-Cherat Range, of Precambrian to Palaeozoic age, consist of sedimentary and meta-sedimentary sequences. Lying unconformably on these are Mesozoic and Tertiary strata. Rocks of the Kalachitta Range in the study area, range in age from Jurassic to Recent. These are mostly limestones, shales and sandstones.

Three main thrust faults (oriented E-W) divide the area into four blocks. The Khairabad thrust marks-off the northern block, the cherat thrust limits the central block and the Hissartang thrust separates the southern block from the Kalachitta range. These thrusts are the splay faults of the HBT, which runs south of the Kalachitta range.

The push from north on these thrusts have been the major cause of the deformation of these Ranges. The big synclinorium in the Kalachitta rocks north of the Indus River is resulted because of the movement on Hissartang thrust.

A model is proposed to explain the structural relationship of the rocks of the Attock-Cherat Range, east of Indus River. During the movement along the Hissartang fault, a splay fault was cutoff in this area, producing a low angle Hissartang back thrust. The rootless patches of Jurassic limestone on Palaeozoic
sequence, east of the Indus River, indicate that the Neozoic strata are thrust over the Palaeozoic rocks.

Previously, the Hissartang thrust was considered to exist beneath the alluvium of Nizampur and Caspallpur Basins (Yeats & Husseinz, 1986). As a result of present work it is relocated just at the southern foot of the Attock-Cherat Range. Similarly the structural style of the central and southern blocks does not display a homoclinal system as was suggested by Yeats & Hussain (1985), but is dominantly a south verging overturned folded system.
CHAPTER ONE
INTRODUCTION
INTRODUCTION

The main objective of this research was to carry out the detailed mapping and to work out the structure of the Attok-Cherat and Kalachitta ranges, in Nizampur area. This area covers most part of the toposheets 43 C/1 and a small portion of 43 C/5. (Latitudes 33.47 N to 33.3 N and longitude 72.0 to 72.17 E). It extends from Amarch village in the west to Dekiher village in the east, and is bounded to the south by the Indus River (Fig.1). The Attok-Cherat Range forms the southern boundary of Peshawar Basin (Fig.2). The Kalachitta Range appears to the south with intervening Nizampur Basin formed by the Indus during the uplift of the Attok-Cherat Range. The whole area is grouped into four tectonic blocks, three in the Attok-Cherat Range (each separated by a thrust fault) and the Kalachitta Range is the fourth block, separated by Hissartang fault (Fig.3).

The rocks of the Attok-Cherat Range can be grouped as

(a) Palaeozoic and older sediments, constituting the northern side of the range, and

(b) Mesozoic and Tertiary rocks, restricted only to the southern part of the Attok-Cherat Range. This range covers an area of about 570 sq.km. in Peshawar district and 80 sq.km. in the Attok district of the Punjab Province. The relief is low on eastern side of the Indus River, while in the west it gradually rises and near Jalala Sar the highest peak has an elevation of 1525 meters. The general trend of the range is East-West between
Dakhner and Miskalan village. In the extreme west it swings to south-west and finally merges into the NE-SW trending Hisampur-Kohat ranges, near Bure Adam Khel village. In Attock plaina, the thick argillite sequence (Dakhner Formation) disappears beneath the alluvium near Kamra town about eight kilometers east of Attock Khurd. These argillites reappear in Hazara and Khyber mountains in the east and west respectively (Tahirkheli, 1970).

A limited portion of the Kalachitta Range is exposed in the area under study. The Kalachitta Range is separated from the Attock-Cherat Range by a well defined Himar Tang Fault. There is a thick alluvial cover between the two ranges, with no outcrop of either range in a wide area. There are definite evidences, (foreign rock fragments and Indus gold-bearing sand scattered on this alluvial flat), which indicate that Indus was once flowing in this area in the Recent past.

The Kalachitta Range dominantly includes Mesozoic rock sequences. Although in Nizampur Basin few outcrops of this range are exposed along streams around Kahi and Nizampur villages, a broad fold exposes rocks of Jurassic to Paleocene age in the southern part of the area. Here the strata of different formations occur in south-verging folds and thin thrust sheets. Locally the Paleocene Lackhart Limestone is making steep cliffs. The whole sequence, upto the Indus River in the south, is making a big synclinorium gently plunging towards south-east. The central part of the fold is entirely comprising of the younger Fatala Formation. Along the limbs the whole synclinorium is cut by several faults, producing multiple repetition and other-
complications in the sequence.

The area is easily approachable by a tarred road from Khairabad to Nitapur, which is then connected to Kohat by an unmetalled road. The NE running streams provide excellent sections, with jeepable tracks leading up into the base of the ranges. Besides, foot tracks connect scattered villages in the area.

The climate of the area is very much like that of Peshawar valley, with cold winters and very hot summers. The area receives very low rainfall and the vegetation is scarce. Most of the cultivated land occurs at the foot of the mountains and in the alluvial plains.

The population is clustered around the streams, where water is available. The major towns are Kohat and Nitapur. Other small villages are located at the foot of the Attok-Cherat Range.

Topographically, the Attok-Cherat Range forms high peaks and steep southward slopes while the Kalachiitta Range in this region occupies low altitudes. The Samana Bul Fornation and Lochar Limestone constitute low lying ridges with a thick alluvial cover at the foothills.

A number of small seasonal and permanent streams (crosscutting both the Attok-Cherat and Kalachiitta Ranges) are present, flowing towards the Indus River. Mostly these streams form a dendritic pattern while in some cases radial pattern is also observed. The sections developed by these streams provide
excellent rock exposures for the study of lithological variations and structural details.

On the whole the Albeck-Charal Range is characterized by rugged topography with several peaks reaching up to 4000 feet (maximum elevation 4800 feet), while in the Karachite Range (only about four kilometers south) there is comparatively much subdued topography (the highest peak being about 200 feet).
Investigations on the geology of the Attack-Cherat Range has started more than a century ago and are still continue.

Nyman (1973) worked here for the first time and placed these rocks in a single undifferentiated unit as Attack Slate Series, considering these as Palaeozoic, with a possibility of being Silurian. On lithological basis, he correlated the Attack Slates and the associated rocks with the Hazara Slates.

Waagen (1865) found some of the Carboniferous fossils in the Attack Slates, but Lydekker (1903) on the basis of his study in Hazara supported Nyman in assigning the probable Silurian age to the Attack Slates. He considered Waagen's evidence for connecting the Carboniferous fossils with the Attack Slates only circumstantial.

Brongniart (1852) for the first time differentiated various lithological unit of this area. On the basis of his observations he regarded the slates and shales to be much younger (not older than Cretaceous). The only older rocks, he mentioned, was the Jurassic limestone.

Middlemiss (1956) correlated these rocks with the Hazara Slates. On the basis of their unfossiliferous nature, he believed that they belong to the great Bajocian Slates series of the outer Himalayas exposed in Dharam and Kumaon areas of India.

Wadia (1952) described these rocks as an undifferentiated series and correlated them with the Hazara and Dogra Slates. Wadia for the first time reported occurrences of basic intrusions in the Attack-Cherat Range.
Cotter (1933) assigned Precambrian age to these meta-
argillites and marked an unconformity between the Attock Slates
and overlying Kiota Limestone (now designated as Chak Jabi Limestone) of Jurassic age of the Kala Chitta hill in the north.
He further mentioned the absence of Palaeozoic and probably also
the lower and middle Triassic sequences between the two ranges.

Gouplon (1937) recognized shale and underlying Hunza Limestone and confirmed it as the Chinarat series of Finkeldei
(1949) of Upper Jurassic age. To the north of Chorat, he mentioned
a strike-slip fault against greatly deformed slates and schists.
He correlated these slates and schists with the Attock Slates.

Pascoe (1950) in his remarks, gives the probable age of late Precambrian to early Cambrian to these slates.

Kishnan (1956), Wadia (1957), Banaser (1959), Baker and
Jackson (1954) and many other workers from the Geological Survey
of Pakistan (1950–55) had been describing these rocks as
undifferentiated slate series of Precambrian age.

Tahirshah (1965, 1970) concentrated on these meta-argillites,
considering their pivotal position in the regional geological
setting of the NW Pakistan. His involvement in the slate/shale
sequence of this region, which was once regarded as an
unattractive problem, started a new era of research. After
seven long years of thorough investigation, primarily oriented
towards the lithological variation and probable age of this thick
sequence, he differentiated thirteen mappable lithological units
in the range, four of which fall in Palaeozoic, four in Mesozoic
and five belong to Tertiary age.
He distinguished the following two groups of lithologies in the range.

(a) Low grade regionally metamorphosed sedimentary rocks of genesis of origin produced in Palaeozoic time. These includes phyllites, slates and limestone and are present on the northern side of the Attock-Cherat Range. These rocks are dipping towards Northwester towards Nowshera mélangé rocks in the north. He correlated these with the rocks of Swabi-Lower Swat in the north, Khakar in the west and Hazara-Kashmir in the east, having similar lithologies and stratigraphic positions.

(b) Mesozoic-Tertiary sequence of sedimentary rocks, over which the metasedimentary rocks are thrustted, are lying to the south of the range. This set of rocks of the Attock-Cherat Range was correlated with the rocks of Kohat, Kalachitta, Salt Range and southern Hazara on the basis of lithology and fossil record.

Ashfaq & Wasi (1969) studied the joint pattern and structure of the Nanki Slates and concluded that the Attock Slates are younger than Nanki Slates. They also observed that Nanki Slates are thrusted over the Attock Slates.

Khan & Attar (1971) by comparing the heavy minerals of the Attock Slates and Nanki Slates, also confirmed that the Nanki Slates are older than the Attock Slates.

Humain (1977) studied these rocks from the economic point of view and suggested the possible utilization of the limestone in the manufacture of portland cement and other chemical industries.

Karim & Salim (1979) recognized Palaeozoic metasediments in the northern part of the Attock-Cherat Range and sedimentary
rocks of Mesozoic-Tertiary age in the southern part of the range. They assigned early to middle Silurian age to Halki Shales and middle Jurassic to the Attock Shales.

Nasir & Shafiq (1980) divided the range into twelve lithological units. They confirmed an older extraneous sequence and a younger set of sedimentary rocks. They also recognized two E-W running thrusts with the southern one being younger.

Hussain (1984) described fourteen mapable units of distinct lithologies in the Attock-Cherat Range. Out of these, four belong to Precambrian, three to Lower Paleozoic, two to Palaeogene, one to Cretaceous and four to Quaternary age. He prepared the first geological map covering the central part of the Attock-Cherat and some exposures of the Kaluchitta Ranges (survey of Pakistan toposheet no. 43 C/1).

Following are some of the new names proposed by Hussain (1984).

<table>
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<th>Old names</th>
<th>New names</th>
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<td>Attock Shales (Tahir Kheli)</td>
<td>Dahner Formation</td>
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<td>Khattak Limestone (Tahir Kheli)</td>
<td>Utch Khattak Limestone</td>
</tr>
<tr>
<td>Raini Hodi Limestone (Nasir &amp; Shafiq)</td>
<td></td>
</tr>
<tr>
<td>Paleogene Limestone</td>
<td>Lochhart Limestone</td>
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<td>Cherat Limestone</td>
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The sequence of tectonic events in the Himalayas and the subsequent development of a structural foreland and thrust belts towards south can be put together into a coherent story of deformation of the region. Although some of the events are blurred by extensive erosion, thick cover of overburden and several other younger features, but the main events can still be traced with fair bit of authenticity through the geological time.

The Himalayan orogeny dates back to late Cretaceous and since then some tectonics is going on till the present day. Evidence of pre-Himalayan orogenic episodes are present (Baig et al., 1987; Kumar et al., 1978; Saxena, 1985) but the structures developed only after the Himalayas started rising. The foreland fold-and-thrust belt is however considered to be comprised of deformed rocks of Gondwana of pre-Cambric age with only thin younger units. (Danuser, 1969; Le Fort, 1975; Singh, 1976; Rued & Alam, 1978; Valdiya, 1980, 1984).

In northern Pakistan, the Himalayas are divided (Fig.4) on the basis of tectonic zonation into nine areas (Yents & Lawrence, 1982). These are, (from south to north):

1. Indian foreland,
2. The Salt Range,
3. The Kohat-Potwar Plateau,
4. The Hill Ranges,
Fig. 4. Subdivisions of Northern Pakistan topographic trend lines shown, with higher terrain in thicker lines. Subsurface Sargodha Ridge in dashed lines. Pliocene-Pleistocene basins are stippled. Locations J B = Jhelum basin, M = Mingora, G = Gilgit, J = Jallpur, H = Harnshaw, NP = Nanga Parbat, PB = Peshawar Basin, P = Peshawar, CB = Campbellpur Basin, A = Abbottabad, I = Islamabad, KB = Kashmir Basin, KP = Khyber Plateau, TISR = Trans-Ladus Salt Range, KN = Kirana Hills, L = Lahore.
5. The intermontane basins of Peshawar and Campbellpur,
6. The southern Kohistan Range,
7. The Nanga-Parbat Haramosh massif,
8. The Main Mantle Thrust (MMT), and
9. The Kohistan Island arc.

The Hill Ranges include the Margala Hills, Attock-Dhair Range, Kalachitta Range, Kohsat Hills and Safed Koh. The deformation of the Hill Ranges is indicative of the tectonic history of the area. Some 40-50 million years ago, the Indian Subcontinent has been penetrating deeper and deeper into the rest of the Asia (Fig. 5) and its present rate of subduction is 5 cm/year. Since collision India must have penetrated at least 2,000 Km into Eurasia. The most spectacular consequence of this collision is the world’s tallest mountain range -- the Himalayas (McNair, 1986). During the northward movement the Indian plate collided with the Eurasian plate, producing 300-400 Km shortening in the Northern Pakistan (Coward, 1983). This shortening is accommodated partly by thickening of the crust and partly by thrusting. Crustal delamination and imbrication can not account for all the displacement; there must also be some lateral displacement of Asia (Tapponnier et al., 1982; Coward et al., 1984). The thrust system produced in the Pakistani Himalayas are (from south to north) (Fig. 6):

1. Main Boundary Thrust (MBT),
2. Main Mantle Thrust (MMT), and
3. Main Karakoram Thrust (MKT) or Northern Megashift.

McNair (1984) and Malinconico (1986) concluded from the
Fig. 5. Plate tectonic setting of Pakistan. K = Karachi.
Gravity measurements that the crust thickens northward.

The continued drift of the Indian plate also produced the folding of the strata. In Hazara-Kashmir syntaxis, south of MBT, the molasse sediments are very much folded. These folds belong to the first phase structures in the molasse sequence but are second and third phase structures in the overlying thrustsed rocks. This sequence continues a general southward propagation of the thrust.

The MBT loops around the Hazara-Kashmir syntaxis in the east and then passes south of the Hill Ranges and merges into the Sargi shear fault in the west. The total displacement here on the MBT and its associated thrusts (only few tens of km.) is not as much as observed in the Indian part. This movement was short lived and had largely ceased by the end of the Pliocene.

Although no definite correlation of Pakistani and Indian Himalaya has yet been done, but the Hill Ranges may correspond to the lesser Himalaya of India. The Hill Ranges are tectonically associated with the Plio-Pleistocene Basins and the southern Kohistan zone. The seismic survey carried out by Smeber et al. (1981) led them to believe that there is a single detachment surface extending from Salt Range to MBT. Yeats and Lawrence (1982) advocate major ramp faults where rocks above the detachment are brought to surface giving rise to Hill Ranges.

The active rise of the 'Hill Ranges which is in progress even today gave rise to Peshawar and Campbellpur Basins. These ranges developed a temporary base level and the streams that flowed in between these ranges filled the depression with thick deposits.
On the basis of the dating of volcanic ash, Burbank (1982) concluded that in the Peshawar Basin sedimentation began around 3 m.y. ago and in Campbellpur Basin, it started about 1.9 m.y. ago.

The thrusting which uplifted the Kalachitta Range and delimitied the southern margins of the Campbellpur Basin had commenced at least 1.7 m.y. ago (Burbank & Reynolds, 1984). Similarly the chronologic study of the Lea Conglomerate suggested a very short interval of rapid tectonic deformation of the Kalachitta Ranges. There are evidences such as the flat lying Lea conglomerate, the gentle dips of Campbellpur basin sediments and the absence of the conglomerate younger than 1.6 m.y., which suggest that the major movement along the MBT was short lived.

The Suan Syncline, developed in the upper Siwaliks, is located 20 km south of MBT near Rawalpindi. The asymmetry is expressed by a northern nearly vertical limb and gently dipping southern limb with Suan River flowing along its axis, which plunges southwest. The deformation of Suan Syncline indicates the initiation of major movement along the MBT. The Lea Conglomerate resulted from the rising Kalachitta and Margala Hill to the north. Burbank & Reynolds (1984) further argue that during the Pleistocene, tectonic disruption migrated systematically southwards across the central and eastern Potwar Plateau.

The history of deformation of the Peshawar and Campbellpur Basins and the Potwar Plateau spreads over a period of last 8 m.y. (Johnson et al. 1986). In Peshawar valley, six major faults
have been reported, with their bordersing the Vai on its north, northwest and south (Tahirkhel, 1980). The local magnetic polarity stratigraphies of these areas have given much information about the timing of events associated with the development of these basins, plateau and ranges. The depositional gap between mid-Miocene and mid-Pliocene in the Peshawar and Campbellpur Basins has been interpreted by Johnson et al. (1986) as the clear indication of initial compressive events in the foreland margin, in late Miocene. Strong deformation of the area north of the Main Boundary thrust zone continued through the Pliocene and culminated with the structural development of the Peshawar Basin about 3 m.y. ago. South of the MBT zone, deformation acquired different styles (including folding, uplift, rotation and faulting). The beginning of deposition in Potwar Plateau, about 2.7 m.y. ago, of detrital clasts of MBT zone terrane suggests significant motion along MBT zone at that time (Johnson et al. 1986). The record of the uplift and deformation of the Kalachihta Range is essentially a record of the history of movement of the Main Boundary Thrust in this region. The oldest sediments exposed in the Campbellpur Basin date back to 1.5 m.y. (Burbank, 1982; Johnson et al. 1982) suggesting that the uplift of Kalachihta commenced prior to this date. Similarly, the oldest sediments found in Peshawar Basin dates back to about 3 m.y., suggesting that the uplift of Attock-Cherat Range occurred before this time. It is still not possible to determine more precisely when the Attock and Kalachihta Thrusts started.

Seeber et al. (1980), from their seismic data, concluded that
a shallow thrust of gentle dip, termed the detachment, underlies the Indo-Gangetic plain and the lower Himalayas. Rupture along this fault resulted in great earthquakes that caused colossal damages over a wide area. The model suggests that much of the Indo-Gangetic plain has a high seismic hazard but in Hazara area the thick layer of Infracambrian salt makes it seismically.

In Hazara and Attock areas, the Pre-Cambrian rocks are represented by well-stratified assemblages with no volcanic rocks. The basement of these sequences is either not preserved or is not recognizable. The Cambrian sequence is exposed in Hazara area but the same is not found in the Attock-Cherat Range. But the unfossiliferous limestone underlying the Siluro-Devonian strata near Nowshera may be Cambrian. Similarly the Darwazai formation of Attock-Cherat Range could be Cambrian (Yeats & Lawrence, 1982). It has been stated (Yeats & Hussain, 1986) that absence of Mesozoic strata from the Attock-Cherat Range may be assumed to have eroded prior to the pre-paleocene uplift. The Jurassic strata is found lying unconformably on Siluro-Devonian rocks in southern part of the Attock-Cherat Range. The Khairabad thrust may be a root thrust, cutting off the Cherat fault (Yeats & Hussain, 1986). Similarly the thrusting south of Peshawar Basin is synchronous with the Main Central Thrust in Nepal and India.

The present tectonic setting is such that a thin-skinned thrusting is taking place in the Salt Range and Pothwar Plateau, while the southern part of Peshawar Basin is reportedly undergoing high-angle faulting and localized folding (Yeats & Lawrence, 1982). The emergence of the Kalachitta Range ponded the
...lucial system north of it and thus resulted in the development of Campbellpur Basin. The sediments are almost undisturbed in this basin, which suggests that there might have been some translation movement but no internal deformation after the formation of the Basin.

The oldest formations exposed at the western end of the Kalachitta Range belong to early Triassic and the oldest strata exposed at the eastern end belong to the late Triassic age. Gardesi (1974) thinks that this is because the Triassic succession is undergoing an attenuation towards southeast and the upper Triassic strata is directly resting over a "soap layer" which could, perhaps, be the Salt Range formation. This presence of "soap layer" is further supported by the structure of the ridge, which suggests the possibility of the role of, at least, local decollement in its development.
LOCAL GEOLOGICAL SETTING

Structurally, the Hill Ranges are separated from the higher Himalayas by Peshawar and Campbellpur Basins and from Potwar Plateau by MBT. These ranges originated in response to the movements along their associated thrusts. The MBT of the Indian Himalayas is represented by an array of thrust faults in the Himalayan Foreland of Pakistan.

The most prominent feature of the Hill ranges is the presence of several thrust faults. These thrusts clearly indicate the tectonic history of this area and is generally dipping towards north. Their general strike is east-west. The southern most thrust (Kalachitta thrust) continues eastward then swings northward to become Margala thrust and loops around Hazara-Kashmir syntaxis to join MBT (Fig.7). It is this fault that can be correctly acclaimed to be the western continuation of MBT, while the small discontinuous thrusts to the north of the Kalachitta Range are its associates. South of MBT, the simalik molasse is folded and faulted in response to the movement and forces on these thrusts.

The Palaeozoic and Mesozoic formations of Potwar plateau, Kalachitta Range and Hazara are easily correlated. Similarly the Eocene strata of Kalachitta and Margala Hills have also been found in the deep bore holes of Potwar Plateau (Fig.7). The Mesozoic and lower Tertiary rocks of Kalachitta can be very easily correlated with the rock units of the Sulaiman-Kirthar Ranges to the west, but eastward they do not have any clear
Fig. 7. Tectonic map of the area between Salt Range and Main Mantle Thrust. Dotted lines mark subcrop boundaries of West-dipping strata beneath Paleocene in Fethar Plateau and Salt Range. (after Yeats & Hussin, 1985)
similarities.

The Kalaichitta Range represents a para-autochthonous pile of thrust sheets, some of which may be nappes (Gardezi, 1974). The Range is much folded, faulted and overturned at least in the northern part. The uplift of the Kalaichitta Range along the MBT has caused the evolution of Campbellpur Basin.

The Attock-Cherat Range is structurally more complicated than the other ranges. The two main thrusts of the region namely Cherat Fault and Hissartang Fault run almost parallel to one another in the central part of the Attock-Cherat Range but coalesce towards east and run NNE as single fault to become Panjel fault in Hazara district.

In addition, some smaller faults which do not fit in regional fault geometry of the area are also present, specially in the area east of Indus River (Fig.1). It is believed during this study that these are high angle listric faults produced within small block of Paleozoic rocks caught up under a back thrust.

Yeats & Huesain (1936) have reported an active fault of considerable extent north of the area in the vicinity of Manki village (Fig.3). This fault has cut and tilted the piedmont deposits in that area.
MINERAL PROSPECTS OF THE AREA

Some of the non-metallic mineral occurrences have been reported from the area. The Attock-Cherat and Kalachitta ranges are composed of sedimentary and metasedimentary formations, which may be favourable for the presence of economic rocks and minerals. These include limestone, slates, shales, clay and sand. Shall occurrences of soapstone, phosphate and graphitic shale have also been noted in the area.

The Lockhart Limestone of Paleocene age can be used in the cement industry. This limestone is chemically analysed for the cement industry with the following results (Husain, 1973).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>31.34%</td>
</tr>
<tr>
<td>MgO</td>
<td>1.85%</td>
</tr>
<tr>
<td>SiO2</td>
<td>3.42%</td>
</tr>
<tr>
<td>Fe2O3</td>
<td>0.50%</td>
</tr>
<tr>
<td>Al2O3</td>
<td>0.94%</td>
</tr>
<tr>
<td>SO3</td>
<td>0.15%</td>
</tr>
<tr>
<td>L/g</td>
<td>40.95%</td>
</tr>
</tbody>
</table>

From the above analysis it appears that the Lockhart Limestone is suitable for manufacture of portland cement and other industrial uses. Good quality limestone can be utilized in various industries. It is mainly used as a:

1. crushed stone,
2. fluxing agent,
3. soil conditioner,
4. source of lime, and
5. chemical raw material (lime ash manufacture).

The easy accessibility and availability of gas, power and water facilities also favor the economic suitability of this limestone in the area. The Lockhart limestone can be used for construction purposes. It is locally used in paving roads, making bridges and buildings, and also for making chips for floors. The extraction of Lockhart limestone is going on in this area and the total reserves are estimated up to about 930 million tons to a workable depth of 60 meters (Hussain, 1978). A huge cement factory has been installed in Cherat which is producing 3,33,000 tons of cement annually.

The Darwaza Limestone is porcellaneous and is used for ornamental purposes and making chips. There are abundant slates and argillite in the Dakhner, Darwaza and Hassartang formations and in the Manki Slates, which need detailed study for their industrial use. Hussain et al (1983) studied argillite and slates for their use in making light weight aggregate. The expanded aggregate is found to be hard, highly cellular and has a tough skin and uniform structural strength. This study shows that Manki slates can be utilized as potential raw material for lightweight aggregate. It is also recommended for use in construction, where weight saving, strength, chemical stability, thermal and moisture resistance and sound insulation are required. Extensive deposits of sand, shale and clay are worked out for various construction purposes.
Impure soapstone is locally mined which occur in Manki Slates near Kund. Phosphatic nodules are found at the top of the Lumshiwal Formation near Kahi and Nizampur area. Graphitic shales are found NE of Inzari village and NW of Kahi village, that are locally mined as graphite (Plate 1). A detailed study of these bodies is recommended for their evaluation and use in industries.
CHAPTER TWO
Pakistan is one of the most attractive places for geologists, because all the rock types ranging in age from Pre-Cambrian to recent are present here. The earliest work dates back to 1851, but still there is some controversy about the ages of different formations which has motivated numerous studies in the area. Geological survey of India is responsible for collecting the data and the first organized work was published in 1897 and later on in 1940 by Sir E.H. Pascoe. In 1960, the geological survey of Pakistan established the “Stratigraphic Committee of Pakistan”, which rearranged the data (collected from different organization) concerning the stratigraphy of Pakistan. In 1977, the same organization published its memoirs in which for the first time the stratigraphy of Pakistan was discussed in an orderly and comprehensive manner.

Pakistan is divided into the following Geological zones.

1. Northern mountain area;
2. Indian shield;
3. Axial Belt;
4. Indus Basin (Lower Indus Basin) Khyber Pakhtoon province (Upper Indus Basin)
   and
5. Baluchistan Basin.

The Attock-Chaurat Range lies in the Axial Belt while the Kailachitta Range lies in the upper Indus Basin.
The Attok-Cherat Range comprises of rocks ranging in age from Pre-Cambrian to Recent. Many geologists worked in the area, as previously discussed, but the most detailed work was done by Professor R.A. Khan Tahirkhel in 1970. He divided the rocks of the area into thirteen mappable units, ranging in age from Palaeozoic to Tertiary (Tahirkheli, 1970).

Recently Hussain (1984) has done the detailed geology and mapped the area on 1:50,000 scale. In addition to four recent to sub-recent deposits, he established ten lithological units in the Attok-Cherat Range. The author with a few changes, follows the trend of Yeats and Hussain (1986) for subdividing and naming these lithologies.

The investigated area is divided into four main blocks (Fig.3), each separated by a major thrust fault. Three of the four blocks lie in the Attok-Cherat Range whereas the rocks of the Kalachitta Range exposed in this area are grouped into a fourth block. Three blocks of the Attok-Cherat Range are: (North to South)

(a) Northern block (upside down) separated from the central block by the Khairabad thrust.

(b) The central block (right side up) is separated by the Cherat thrust from the

(c) southern block (right side up).

The arrangement and stratigraphy of the three blocks of the Attok-Cherat Range is as follow.
CAINozoic

---unconformity---

[ Lockhart Formation ]

-----FAULT-----

SOUTHERN (3rd) BLOCK

PALAEOZOIC

[ Imari Limestone ]

[ Hissartang Formation ]

[ Darwaizai Formation ]

----------

CHERAT THRUST
----------

PROTEROZOIC

[ Dakhner Formation ]

CENTRAL (2nd) BLOCK

----------

KHAIRABAD THRUST
----------

PROTEROZOIC

[ Utch Khattal Formation ]

NORTHERN (1st) BLOCK

[ Shankot Bala Formation ]

[ Khanki Formation ]

In the southern block, the Murree and the Patala Formations are wellbedded but the Lockhart Limestone occurs in the form of isolated and scattered exposures. The Lockhart Limestone is distributed throughout the Dakhner Formation as isolated patches and it is thought that this limestone is brought down by some tectonic episode to its present position.

The fourth block (Kalahitta Range) is separated by the Hissartang Thrust from the Attock-Cherat Range (Fig.1) and it lies to the extreme south of the area of study. The stratigraphy of the Kalahitta Range is well established. The whole range comprises of eighteen lithostratigraphic units of marine and non-marine origin, ranging in age from Triassic to Recent. The oldest disconformity in the range is of Late-Triassic period. Other
disconformities are, at the close of Middle Jurassic, Middle Cretaceous, at the Cretaceous-Paleocene boundary and the Middle Eocene-Oligocene disconformity. (Akhtar et al., 1993).

The stratigraphic units of the Kalachitta Range exposed in the project area are as follows:

CENOZOIC
[ Recent to Sub-recent deposits ]
[ Patala Formation ]
[ Lachnait Limestone ]

---------UNCONFORMITY---------

NEOCENOIC
[ Kawagarh Formation ]
[ Lumshwai Formation ]
[ Chichali Formation ]
[ Samaana Sruk Formation ]

--------- HISSARTANG FAULT ---------
DETAILED STRATIGRAPHY OF THE ATTACK-CHORAT RANGE

PRECAMBRIAN

MANKI FORMATION

The Manki formation (Hussain et al. 1981), previously called the Manki Slates by Tahirkhel (1970), is the oldest formation in the area which is extensively developed in the northern foothills of the Attack-Chorat Range. It lies to the north of the Khareabad Thrust. Its type locality lies to the south of Nowshera as an isolated hillock, called Manki Bhor. The name "Manki Formation" is not yet approved by the Stratigraphic Committee of Pakistan.

The Manki Formation is widely spread over the area north of Khareabad fault, on both sides of the Indus River. The thickness given by stratigraphic committee of Pakistan is about 300 meters, while Hussain (1984) measured the maximum thickness up to 600 meters.

LITHOLOGY

The Manki Formation is composed of thinly bedded phyllite, slate, slaty shale with lenticular sand bands (collectively called argillite) and subordinate lenses of Limestone. The slaty cleavage in argillite is developed at many localities. This cleavage is parallel to the bedding but oblique in the cores of folds. Ripple marks are developed in the sandy bands of Argil-
lite. Color of Argillite on fresh surface is light grey or light greenish-grey, while it is dark grey and brownish-grey on weathered surface. The diamictite intrusions and quartz veins are common in argillite (Tahirkheli, 1970). Limestone occurs most prominently in the basal part in the form of pockets and lenses and is usually thin to medium bedded and finely crystalline. Two types of limestone are present, one is light to dark grey with calcite veins and the other is thinly bedded argillaceous and yellowish brown.

CONTACT RELATIONSHIP
The upper contact of the Maniki Formation is gradual (conformable) with the Shahkot Bala Formation at its normal stratigraphic position, while the lower contact is not exposed.

AGE & CORRELATION
Tahirkheli (1970) considered the Maniki Formation to be Palaeozoic, based on the fossils (bryozoans) collected from the Shahkot Bala Formation, but the sampling locality has not been relocated. Tahirkheli (1982) concluded that the Maniki Formation is of Precambrian age, based on the radiometric dates obtained on Rb-Sr method (Calkins et al., 1975; Crawford & Davies, 1975), for similar rocks of the Hazara Formation. The Maniki Formation is correlated with the Hazara Formation of Pre-Cambrian age.
SHAHKOT BALA FORMATION

The previously named "Shahkot Bala Limestone" is now known as the Shahkot Bala Formation. This formation is exposed in the north-eastern part of the investigated area, which extends in the EW direction. The Shahkot Bala Formation attains its maximum thickness between Shahkot Bala village and Shakhai nala in the north-western foothills of the Cherat Range.

The Shahkot Bala Formation has restricted occurrences as compared to the other metasedimentary rocks of the area. These rocks form small isolated pockets in the hillock around Kund village. The thickness of the formation is mapped and is variously quoted as 70 m. in Stratigraphy of Pakistan; 30 m. by Hussain et al. (1983); and 72 m. by Tahirkhel (1970).

LITHOLOGY

The Shahkot Bala Formation is composed of limestone in the lower part succeeded by argillite in the upper part. The dominant dolomitic limestone is thin to thick banded and crystalline. The limestone is well jointed, fractured and is yellowish-grey to brownish-grey. It occurs in banded form, with alternating calcareous and argillaceous layers. Hydrothermal quartz veins are common in this limestone. The argillites (sandy and slaty shale) are greenish-grey to dark grey in color. They are less plastic as compared to the Monkii Formation. The argillites are thin to medium banded, compact and usually cleavages are produced along more
than one plane. Diabase intrusions are present in this part of the formation.

CONTACT RELATIONSHIP

This formation has conformable contact with the overlying Utch Khattak Formation and the underlying Manki Formation at its normal stratigraphic position.

AGE and CORRELATION

Tahir Kheli (1970) put Shohiot Bala Formation in the Paleozoic system on the basis of untraceable Bryozoans, but Hussain (1983) assigned Precambrian age to this formation on the basis of its normal stratigraphic relationship with the underlying Manki Formation. This formation is correlated with the Hazara Formation of Precambrian age.

UTCHE KHATTAK FORMATION

The Utch Khattak formation consists predominantly of limestone with subordinate shales. It extends all along the Khairabad thrust (E-W) separating the Manki Formation from the Dakhner Formation. Tahir Kheli (1970) named it as "Khattak Limestone" and Hussain (1983) used the name "Uutch Khattak Formation" for these rocks. The best exposures are on the eastern side of the Indus River. The name "Uutch Khattak Formation" is not yet approved by the stratigraphic committee of Pakistan. The formation is very prominent on the eastern side of the Indus River, where it forms ridges and escarpments.
Approximate thickness of the formation is 50 m. (Hussain, 1964)

**LITHOLOGY**

The Jeth Khattak Formation consists mainly of light grey to yellowish-grey limestone with subordinate grey and ferruginous shale on the top. The dolerite intrusions are present in this formation. The limestone is thin to medium bedded, medium to fine grained and crystalline, with dark grey argillaceous streaks and laminations. At places it shows stromatolitic structures. The limestone can be divided into the following three members on the basis of lithology, (Isharkheli, 1970).

1. The lower bed is thin to thick bedded, fractured, displaying a typical nodular feature on weathering. It contains argillaceous intercalations, usually surrounding the nodules. The distribution of this bed is very wide.

2. Thin bedded, crystalline limestone, confined to the middle horizon. It is homogenous and contains light colored argillaceous and calcareous layers usually developed parallel to the bedding plane.

3. The top bed is thick bedded to massive. It is restricted only to a few localities, containing some clastic material derived from the older Manki and the Shahkot Bala Formations.

The shale also forms a thick unit in this formation. It is light grey to greenish-grey, thin bedded, clayey and spotted with ferruginous encrustations.
CONTACT RELATIONSHIP

The upper contact is thrust against the Dakhner Formation and the lower contact is conformable with the underlying Manki Formation.

AGE AND CORRELATION

The Utch Khatkak Formation is totally devoid of fossils. It contains clasts of Shankot Bala and Merki Formations, suggesting that the Utch Khatkak Formation is younger than both the formations. The age assigned to this formation is late Pre-Cambrian on the basis of its normal stratigraphic relationship with the underlying Shankot Bala Formation. It is correlated with the Miranjani Limestone of the Hazara Formation and also with the limestone interbedded in the Landikotal Slate.

CENTRAL (2nd) BLOCK

DAKHNER FORMATION

These rocks were first described by Wynne (1873) as "Attock-Slate Series". Tahir Khel (1970) termed these rocks as Attock Shales. Hussain (1984) called it as the Dakhner Formation, after a small village, Dakhner, located in the eastern part of the range. None of these names are formalized by the stratigraphic committee of Pakistan. The name Dakhner Formation is adapted here because all the lithologies of the formation are exposed here.

This formation is widely distributed in the Attock-Cherat
Range. It is the thickest lithological unit lying in the middle of both the Khairabar and Chorat thrusts. In the east, it starts as isolated hillocks near Kohta and gets thicker towards the west. In the extreme west of the Attock-Cherat Range, it attains its maximum thickness. The thickness in the type locality is about 1000 m, but it is greater in the western part of the range.

**Lithology**

The Dahunar Formation consists of a thick sequence of argillite, quartzite and subordinate limestone. Argillite, with subordinate siltstone and dark sandstone, is dark grey to greenish-grey on fresh surface. It is thin to medium banded, irregularly stratified, jointed, fractured and folded (Plate 2). Due to the typical fracture development, the weathering product is sharp and splintery. Ripple marks (Plate 3), cross-bedding and graded bedding are the sedimentary structures present in these rocks.

The quartzite is fine to medium grained, light grey to dark grey, or brownish in color. It is hard and has poorly preserved cross-bedding. Limestone with interbedded chloritic material is dominated at the base of the formation. It is light grey to yellowish-grey and weathers to rusty yellowish-brown color. Some isolated outcrops of the Paleocene Lokhart Limestone are present in the argillite (Plate 4). The origin of this limestone is controversial.

The diabase intrusions are absent, except for one in the
Limestone, which is on the eastern side of the Indus River.

**CONTACT RELATIONSHIP**

Its upper contact has a thrust relationship with the Uch-Khattak Formation while the lower contact is faulted against the Inzari Limestone and Historiang Formation (Silurian-Devonian), the Lockhart Limestone, the Patala and the Murree formations (Tertiary) at different places.

**AGE & CORRELATION**

Tahirkhel (1979) assigned middle Jurassic to Cretaceous age to this formation on the basis of fossils found in the limestone, but that locality of fossils has not been relocated. The earlier workers did not find any fossils but on the basis of observed stratigraphic position and structural affinity, the Dakhter Formation is assigned a Late Precambrian age.

The Dakhter formation is correlated with the similar rocks of Hazara and Landikotal areas.
SOUTHERN (3rd) BLOCK

PALAEOZOIC (SILURIAN-DEVONIAN)

DARWAZAI FORMATION

Tahirkhel (1970) for the first time used the name "Darwazai Formation" for this stratigraphic unit, exposed in the extreme south of the Attock-Cherat Range. It is the oldest formation of Palaeozoic age in the southern block of the range. The best exposures occur in the Darwazai village, lying in the foot of the southern block. The name Darwazai Formation is not yet formalized by the stratigraphic committee of Pakistan.

The Darwazai Formation is exposed on the eastern side of the Indus River, near Dakhner village and then extends (E-W) along the range upto Darwazai village in the west. Small discontinuous outcrops are exposed further west, where it vanishes beneath the piedmont deposits. A few isolated outcrops are also exposed near Inzari and Amirah villages. The formation attains its maximum thickness (~270 m) in Darwaza-Charpani village.

LITHOLOGY

The Darwazai Formation consists of limestone in the lower part and shale in its upper part. The limestone is white to light greenish, which weathers to brownish and greenish color. It is fine grained, thin to medium bedded, fractured, jointed and devoid of fossils (Plate 5). It is porcellanous and contains...
phyllites with numerous staurolites. The schists are red, maroon and dark gray in color (Plate 6). It is fine-grained, thinly bedded and splits easily into thin layers of uniform thickness. Small dolerite dykes and sills are common in this formation.

CONTACT RELATIONSHIP

The lower contact of the Darwazai Formation is buried under piedmont deposits while the upper contact is gradational with the overlying Hissartang Formation.

AGE & CORRELATION

Tahirkheli (1970) correlated the Darwazai Formation with the Kingrially Formation of Salt Range and Kalachitta hills and assigned a late Triassic age. There was no fossil evidence to support this age. Hussain (1984) lithologically correlated these rocks with the similar rocks exposed in Nowshera area and assigned a Silurian-Devonian age.

HISSARTANG FORMATION

Tahirkheli (1970) used the name "Hissartang Formation" for Inari limestone and the Hissartang Formation. Hussain et al. (1962) divided them into two separate formations. The type locality is Hissartang village, located on southern foothills of the Attock-Cheraot Range. None of the above names are approved by the stratigraphic committee of Pakistan.
The Hissar lang Formation runs all along the southern face of the Attock-Churut Range. It starts from the eastern bank of the Indus River, beyond which it goes under the Diamir Formation. It extends westward for about 50 km, up to the Jaimah Bar, without any interruption. The thickness of the formation is about 330 meters at the type locality. (Arif et al, 1986).

**Lithology**

The Hissarlang Formation consists of alternate quartzite and argillite bands. Quartzite is white to light grey, while greenish-grey, rusty-brown and pinkish-brown are the common color on weathered surface. It is fine grained, hard, thin to thick bedded and sometimes crossbedded. Reddish-brown ferruginous specks and coatings are common in quartzites. Argillites are variegated in color. These are fine grained, thin to medium bedded and fractured, the slaty cleavage is poorly developed and is oblique to bedding. They are also marked by reddish-brown ferruginous encrustations. These alternate bands of quartzite and argillite are due to the small scale transgression and regression. (Sultan & Arbab, 1996).

**Contact Relationship**

The lower contact of the Hissarlang Formation is conformable with the underlying Darwaza Formation, while the upper contact is sharp and normal with the Inseri limestone and is faulted against the Sakhrer Formation on the eastern side of the Indus River.
Tehirkheli (1970) placed these rocks in Ordovician, but Hussain (1984) correlated these with the Main Ganda quartzite, which has been assigned Silurian–Devonian age. It is also correlated with the quartzite of the Khyber Agency of Silurian–Devonian age. On the basis of these correlations and its stratigraphic position, Hissartang formation can safely be placed in Silurian–Devonian age.

**INTARI LIMESTONE**

This limestone was considered by Tehirkheli (1970) as the upper part of the Hissartang formation. Hussain (1984) differentiated it as a separate stratigraphic unit and named it as the Intari Limestone, after the Intari village, located on the southern slopes of the Attock–Cherat Range. This name is not yet formalized by the stratigraphic committee of Pakistan.

The Intari Limestone crops out near the main Attock–Hisarpur road in the east and runs continuously all along the Attock–Cherat Range up to the north eastern slopes of Jalala Bar in the west. The limestone gradually thickens west of Hissartang village. It is very widely distributed on the eastern side of the Indus River. The maximum thickness (~170 m) is recorded by Shaukat et al. (1986).
LITHOLOGY

This formation consists of two varieties of limestone, the thin bedded and the thick bedded to massive limestone.

The thin bedded limestone is white, light grey, yellow and yellowish-brown. It is fine to medium textured crystalline limestone with several small folds in it (Plate 7a). The limestone contains thin lenses of grey shale and shaly bands usually developed near the middle part. The massive limestone is dark grey and is fine grained, occupying the middle part of the thin bedded limestone. Fine lamination is present at the contact with the Hissartang Formation. Stylolites are present, manganese stainings and dendrites are common.

CONTACT RELATIONSHIP

The formation has its upper contact in thrust relationship with the Dakhna Formation in the eastern side and a well marked unconformity is present between the Lockhart Limestone and the Inzari Limestone in the western side. The lower contact is sharp and normal with the Hissartang Formation.

AGE & CORRELATION

The age assigned is Siluro-Devonian and it is correlated with the limestone of the Nowshera Formation of the same age.
The cliffs forming Lockhart limestone in brown, brownish-grey and light to dark grey in color. It is massive, hard, compact, nodular, and medium to thick bedded. On freshly broken surfaces it gives fetid smell. Minor intercalations of grey to black, thinly laminated shale and calcite veins are common. It has a conformable contact with the overlying Patala Formation and faulted contact with the underlying Inzari Limestone. Foraminifera are abundant in the Lockhart Limestone which indicates Paleocene age.

**Patala Formation**

The Patala Formation comprises predominantly of alternate layers of limestone and shale (Plate 3). Sandstone is also present at some places. Limestone is dark grey to yellowish-grey, nodular at places, and thin to medium bedded. Shale is soft, splintery and thin bedded. It is dark greenish-grey and is interbedded with limestone. Sandstone is brownish-grey and thinly bedded with poorly preserved cross-bedding. Laterite is also present, so it has an unconformable upper contact with the Murree Formation. On the basis of fossils, the age assigned to this formation is late Paleocene to early Miocene.
MIOCENE

MURREE FORMATION

The name Murree Formation is approved by the Stratigraphic Committee of Pakistan after the Murree hills in Rawalpindi district. Type locality is to the north of Dhok Faike in the Attock district. This formation is less exposed in the project area as compared to the rest of the formations. It is exposed near Tharkhel village, about 10 km south west of the old Attock bridge, and extends continuously up to Dhang Khwar in the west. The Murree Formation extends in the E-W direction along the strike. Thickness in this area is about 30 meters.

LITHOLOGY

The formation is composed of alternate sandstone, siltstone and shale with subordinate intraformational conglomerate in the base. The dominant sandstone and siltstone are red, purple, greenish-grey and thin to medium bedded. Calcite veins are the common features present. The red, purple thinly bedded shale weathers to clayey material. The shale is fissile and splits easily along bedding plane.

CONTACT RELATIONSHIP

The upper contact is faulted against the Dakhner Formation, while the lower contact is unconformable with the underlying Pattala Formation.
On the basis of its stratigraphic relationship and some poorly preserved enamel remains, Fatmi (1973) assigned an early to middle Miocene age to the Murrar Formation.
MIDDLEMISS (1896) was first to study the rocks of the Samana Suk Formation. This name is adopted after the Samana Suk limestone of Davies (1930). The stratigraphic Committee of Pakistan approved the name "Samana Suk Formation" for these rock types. Davies (1930) did not indicate its type locality and Fatei (1968) designated a section north-east of the Samana Range in Kohat district, as its type section. The same name is also extended to the similar limestone sequences in Salt Range and Trans-Indus ranges.

This formation is widely distributed in the Trans-Indus Ranges, Kohat, Kalachitta, western Salt Range, Hazara and Nizampur areas. The Samana Suk Formation is one of the oldest formation of the Kalachitta Range in Nizampur area. It is found on both the sides of the plunging synclinoirum. Most of it is covered by alluvium but there are good exposures near Kahi village, Mama Khel (SE of Nizampur) and in Much Tangi Khwar. The southern most and the central exposures run along the strike (E-W) for several kilometers. Alluvium has covered the outcrops north and north-east of Kahi village.

The thickness at the type locality is 166 m. and in eastern Kohat, Kalachitta, and Hazara, the thickness varies from 190 to 366 m. In Nizampur area the thickness is about 227 m. (Hussain, 1984).
LITHOLOGY

At the type locality, the formation is comprised of grey to dark-grey, medium to thick bedded limestone with subordinate marl and calcareous shale intercalations. The shale is thin bedded. Marl is yellowish-grey, calcareous and nodular at places. A brownish-grey, hard, medium to coarse grained glauconitic sandstone is also present.

In Hazara, Kalachitta, and Nizampur areas, the limestone is thin to thick bedded and includes some dolomitic and ferruginous sandy oolitic beds. This limestone is grey to dark grey and yellowish in color. It is partly argillaceous.

CONTACT RELATIONSHIP

The lower contact of the formation is transitional with the Shinwari Formation and is placed at the top of the sandstone unit of the Shinwari Formation. The upper contact is disconformable with the Chichali Formation. The lower contact is not exposed in the study area.

AGE & CORRELATION

Fatmi (1968) and Fatmi & Cheema (1972) reported brachiopods, ammonoids, bivalves, gastropods and crinoids from the uppermost beds in the Surghar Range. These fossils indicate an early to Middle Jurassic age. This formation is correlated with the Chilten Limestone and the Hazar Dink Formation of lower Indus Basin.
The term Chichali Formation was used by Danilchik (1961) and Danilchik & Ghaz (1967) after the Chichali pass in the Saragar Range in Mianwali district. This name is extended to include rocks that disconformably overlie the Aamana Sak Formation in Hazara, Kalachitta and Kohat areas. This name is formalized by the Stratigraphic Committee of Pakistan.

Typical lithology of this formation is widely distributed in the Trans-Indus ranges, northern Kohat ranges, Kalachitta Range, and southern Hazara. In northern Hazara, the formation shows a facies change and is similar to the Spiti Shales.

In Nizampur area this formation is rarely exposed and has a few meters thickness. The extension is not long as it abruptly pinches out within a few meters. In the project area it is found in Khwari Khwar, the thickness is more or less 20 meters in the southern side of the stream. These rocks are also present in Much Khwar section. In Chichali area, the thickness varies from 50 to 70 meters and in the Nizampur area its thickness is 10 to 25 meters.

**LITHOLOGY**

The Chichali Formation consists of sandstone and shale at its type locality. The sandstone is dark green and greenish-grey which weathers to rusty brown and is also glauconitic. The dark grey, bluish-grey, sandy, silty and glauconitic shale occurs in
the lower part.

In Nizampur area this formation consists of sandstone and shale. The medium grained sandstone is dark grey to black and greenish-grey. It is glauconitic and contains reddish-brown and yellowish ferruginous staining. The sandy, silty and glauconitic shale is thin bedded and phosphatic. Pyritic nodules are common in shale.

CONTACT RELATIONSHIP

The upper contact of the formation is sharp and normal with the overlying Lumshihwal Formation. The lower contact is disconformable with the Rannana Fluk Formation in the area of investigation.

AGE & CORRELATION

Speth (1959) and Fatmi (1968, 1972) reported some ammonoids from western Salt Range and Trans-Indus ranges. On the basis of these ammonoids, some belemnites and molluscs, late Jurassic to early Cretaceous age has been assigned to this formation. These rocks are correlated with the Sembar Formation of the Axial belt and with the Goru Formation of the Sulaiman and Kirthar Provinces.

LUMSHIHAL FORMATION

Gee (1949) introduced the name Lumshihwal Formation which was formalized by the Stratigraphic Committee of Pakistan. The formation is not fully exposed in Lumshihwal nala, Danilchik and
Shah (1967) designated its type locality one kilometer north of the Lumshiwal nala.

This formation is widely distributed in Kohat, Nizampur, Kalachitta, and Hazara ranges. Surghar Range and Sheikh Budin hills having the typical lithology of this formation. In western salt range, towards east, the formation thins out and ultimately disappears. In the area investigated, the formation is widely distributed at Wuch Khwar, Khwari Khwar, and along the Khairabad-Nizampur road near Kahi village.

The thickness at the Lumshiwal nala and the Chichali pass is 80-120 meters and 38 meters respectively. In Nizampur area, the thickness of the formation is about 100 meters.

**Lithology**

At the type section, Salt Range and Trans-Indus ranges, the Lumshiwal formation is mainly composed of arenaceous facies. Calcareous facies is developed in Hazara, Kalachitta and Kohat areas. This calcareous facies is developed at the upper part of the formation, which is designated as the Wuch Khwar limestone and Marl member. (Fatmi, 1972).

Fatmi (1968,1972) designated three principal reference sections of this formation because of considerable variations in the lithology (facies change) and thickness. They are:

a: Fort Lockhart road section in the Samana Range,

b: Wuch Khwar section in Nizampur area, and

c: Jhamiri Village section on Haripur Jabrian road in Hazara.
In the type locality and other sections of the Trans-Indus ranges, the lithology consists of sandstone with shale towards its base. The light grey, felspathic, ferruginous sandstone is cross-bedded and contains carbonaceous material in the upper part. The shale is silty, sandy and glauconitic. At many places the formation is mainly of marine origin, representing mixed sandy and calcareous facies.

In Nizampur area, the formation consists of quartzose sandstone in the lower part followed by sandstone and limestone. The light grey to brownish-grey quartzose sandstone is hard and contains subordinate silty partings. The sandstone is greenish-brown to greenish-grey, medium grained, thin bedded, flangy and glauconitic. The yellowish-grey to brownish-grey limestone is thin to medium bedded, hard and contains subordinate marly beds. The upper part of this limestone is glauconitic and contains phosphatic nodules. It also contains belemnites, ammonoids, and other mega fossils (Fatmi, 1973).

CONTACT RELATIONSHIP

The upper contact of this formation is disconformable with the overlying Kawagarh Formation while the lower contact with the Chichali Formation is sharp and normal.

AGE AND CORRELATION

In the upper beds of the Wuch Khwar section and in the Samana Range, abundant fossil casts of brachiopods, ammonoids, belemnites, bivalves, gastropods, and echinoids are present (Speth, 1930; Fatmi, 1958). On the basis of *Trigonia* sp. Neitha
and other fossils (Fatmi, 1973), an early Cretaceous age is assigned to this formation.

The rocks of the Lunshival Formation are correlated with the Goru Formation of the Axial belt and lower Indus basin.

**AWAGARH FORMATION**

The Kawagarh Shale of Cotter (1933) is formalized as the Kawagarh Formation after the Kawagarh hills, north of the main Kalachitta Range, in the Attock district. In the eastern Kohat, Nizãmpur, northern Kalachitta including Kawagarh hills and parts of southern Hazara, the calcareous shale and marl lithology is typically developed. In western! Kohat, the formation is sublithographic limestone, which is thick bedded in the upper part and thin bedded in the lower part.

The thickness varies at different localities. In its type locality, the thickness of the Kawagarh Formation ranges from 40 to 70 meters and in Nizãmpur area the thickness is about 110 meters.

**LITHOLOGY**

At its type locality and adjoining areas of northern Kalachitta, Nizãmpur and eastern Kohat, the formation consists of dark-grey marl which weather light grey to brownish-grey and cleaved calcareous shale. Interbeds of nodular, argillaceous
Limestones also occur in its westerly extension in Kohat area.

In Nizampur area, the Kawagarh Formation consists of marl with subordinate interbedded limestone. The marl is yellowish-grey to brownish-grey, thinly bedded and contains terrigenous encrustation along fractures and joints. The limestone is grey to yellowish-grey, nodular and argillaceous.

CONTACT RELATIONSHIP

As the Hangu Formation is not exposed in the investigated area, the upper contact of the formation is unconformable with the Lockhart Limestone and is represented by the presence of laterite. In other areas, the upper contact with the Hangu Formation of palaeocene age is disconformable.

AGE & CORRELATION

The Kawagarh Formation is poor in mega fossils except in Darsamand area where some ammonoids are recorded from the basal part (Fatmi, 1968). Smaller foraminifers are well distributed throughout the formation in the Kalachitta Range and Kohat area (Latif, 1962, 1970 a,b). Some foraminifers are also reported from the southern Hazara (Butt, 1969). In Nizampur area these rocks contain some of the mega or microfossils. On the basis of smaller foraminifers, including different species of *Globotruncana*, this formation has been assigned a late Cretaceous age (Latif, 1962, 1970). This formation is correlated with the Dac Sandstone, Mughal Kot Formation, and Parh Limestone of the Axial belt and the Sulaiman and Kirthar Provinces.
Cainozoic

**Lockhart Limestone**

The term Lockhart Limestone was introduced by Davies (1930 a) for a Paleocene limestone unit exposed in Kohat area. The same name was approved by the Stratigraphic Committee of Pakistan and extended to Kohat-Potwar and Hazara areas, having similar lithology. An exposure near Fort Lockhart in the Samana Range has been designated as the type section.

The limestone is widely distributed in the Upper Indus Basin, Kohat-Potwar province, Kalachitta and Hazara areas. In Nizampur, it is widely spread over the area as compared to the other rock types of the Kalachitta Range. The most extensive exposures are to the south of Nizampur and NNW of the Indus River, following the E-W trend. The Lockhart Limestone is also found, although mostly in patches, in the Attock-Cherat Range. At the type section, the thickness is 60 m. and in Nizampur area it is 250 m. (Hussain, 1934).

**Lithology**

At the type locality, the limestone is grey and medium to thick bedded. At the basal part, the limestone is dark to bluish-grey, flaggy and splintery. This limestone gets rubbly and brecciated in other parts of Kohat area but the overall lithology remains the same. In Nizampur area the limestone is light grey to dark grey, hard, nodular, medium to thick bedded and massive. Some minor intercalations of dark-grey to black, thinly laminated shales are found at places. On fresh surfaces calcareous and
sandy zones are often noted in Lockhart Limestone, in Nizampur area. The calcareous part contains abundant small foraminifers and the other part is without fossils. The Lockhart Limestone is bituminous and gives off fatig smell on freshly broken surface.

CONTACT RELATIONSHIP

The Lockhart Limestone conformably overlies the Hange Formation and underlies the Patala Formation in normal sequence.

In Nizampur, the upper contact of the limestone is conformable with the overlying Patala Formation and the lower one is marked by an unconformity (laterite) with the Kaliyar Formation.

AGE & CORRELATION

On the basis of abundant foraminifers, corals, molluscs, echinoids and algae, the Lockhart Limestone has been assigned a Paleocene age. This limestone is correlated with the Bara Formation of lower Indus Basin, lower part of the Bouncer Formation of Aral Felt and with the Rakhshani Formation of Baluchistan Basin.

PATALA FORMATION

Davies and Pinfold (1937) were the first to use the name Patala Shale. The Stratigraphic Committee of Pakistan formalized the name Patala Formation after the Patala Nala in the western Salt Range, Mianwali District. It's usage was extended to other parts of Kohat-Potwar and Hazara areas.
The Patala Formation with variation in lithology is widely exposed in the Kohat-Potwar and Hazara areas. It is also proved to be present in the subsurface of the Potwar area. In Nizampur area the Patala Formation is in the core of the synclinorium and is tightly folded. Coal seams of economic value are also present in this formation in Landot area. At the type locality, the thickness of the formation is 90 m. and in Nizampur area the thickness is 75 m. (Hussain, 1984).

**LITHOFOLGY**

The Patala Formation at its type locality consists of shale with subordinate marl, limestone and sandstone. The dark greenish-grey shale is selenite bearing at different places and also contains marcasite nodules. The marl is dark grey and splinterly. The limestone is white to light grey and nodular. Yellowish-brown and calcareous sandstone is present in the upper part as subordinate interbeds.

In the area investigated, the Patala Formation consists of alternations of shale and limestone with subordinate sandstone. The thinly bedded shale is dark greenish-grey, and the limestone is dark grey to yellowish-grey, hard and thin to medium bedded. The thin bedded sandstone is brownish-grey and shows poorly preserved crossbedding. The limestone of this formation is widely distributed in Much Tangi Khwar in Nizampur area.
CONTACT RELATIONSHIP

The Patala Formation conformably overlies the Lockhart Limestone. It is overlain conformably by theNama Formation in the Salt Range and the Gurghar Range, by the Panoba Shale in Sotat area and by the Margala Hill limestone in Hazara and in the Kalachitta Range. In Dizamur, being the youngest formation of the range, this unit lies in the core of the synclinorium (Fig.12).

AGE AND CORRELATION

In the Salt Range and Gurghar Range, the Patala Formation is fossiliferous and contains abundant foraminifers, molluscs, and ostracodes. On the basis of these fossils, Late Paleocene to Early Eocene age is assigned to this formation (Fatmi, 1973).

The Patala Formation is correlated with the Lakhra Formation, the upper part of the Dungan and Rakhshani Formations and lower part of the Ghazij and Laki Formations of the Lower Indus Basin, the Axial belt and the Baluchistan Basin.
CHAPTER THREE
STRUCTURAL GEOLGY
STRUCTURAL GEOLOGY

GENERAL STATEMENT OF THE PROBLEM

As a part of the routine field work during a field camp at Nizamapur and later on the basis of field reports compiled by some M.Sc. students working in the Attock-Cherat Range, some new aspects of structural and stratigraphic relationship of different rock units were observed.

The area is traversed by three major E-W trending thrusts which are produced by the stresses operating from the north. From north to south these faults are:

1. The Khairabad Thrust
2. The Cherat Thrust and
3. The Hissartang Thrust

The Khairabad Thrust serves as a boundary between the Pre-Cambrian slates, phyllites, quartzites, limestone unit and the unfossiliferous flysch deposits of the late Pre-Cambrian (?) age. The later is recently named as Dakher Formation (Yeats & Hussain, 1986).

Southward, Dakher Formation is thrust over the Siluro-Devonian sequence along Cherat Fault. The Siluro-Devonian rocks are relatively more competent than Dakher Formation and are deformed and folded to a lesser degree. Inziari Limestone near the fault shows a constant vergence to the south. Although the characteristic tight isoclinal folding of Dakher Formation
(Plate 10) is not the common feature of these rocks, but a major overfold verging to south has been identified.

The Missartang Thrust marks the boundary between the Altitock-Cherat and Kalachitta ranges in Nizampur area. Along this fault the Siluro-Devonian rocks are thrust over the Mississippian rocks. The movement along this fault deformed the rocks of the Kalachitta Range. The first appearance of outcrops of Kalachitta Range after the alluvial cover in this area are folded into a synclerium with folds again verging to the south.

The Nizampur quadrangle map (1:50,000) produced earlier (Hussain 1984), is on a regional basis and does not include some of the smaller outcrops appearing from the alluvial cover at the southern foot of the Altitock-Cherat Range (Fig.1). These outcrops are of Darwazai Formation, which is the oldest unit of the Paleozoic sequence in the area, and Jurassic limestone exposed near Tarkhel village. These two units are important because they modify the structure and the placement of Missartang thrust to a great extent.

The discontinuous chain of small hillocks, west of Tarkhel village, exposing the lower limestone unit and an upper shale unit of Darwazai Formation, gives an indication of overturning of Lower Paleozoic sequence on itself and thus forming an overturned fold with its southern limb truncated against the Missartang thrust. The shale unit of this formation can be seen underlying the calcareous unit in these outcrops (Plate 11).

The Jurassic Limestone (Yamuna Sub Formation) is found at
the foot of the Attok-Cherat Range as low lying outcrops partly visible in quarries on both the eastern and western side of Tarkhel village. It dips between 10 and 20° toward north, and has a sharp contact with the Hissartang Formation which dips steeply towards north. At Amirsh village, towards west, the same limestone has been mapped as a small outcrop directly in contact with Darwazai Formation with intervening Hissartang Fault (Plate 13). Towards east the continuation of the same fault is shown under the alluvium extending upto the Campbellpur Basin (Yeats & Hussain, 1961). The Hissartang Fault brings Paleozoic sequence of the Attok-Cherat Range over the Mesozoic and Paleocene rocks of the Kalachitta Range. The contact between the Samana Buk Formation (Jurassic) and the Hissartang Formation (Paleozoic) at Tarkhel village (Fig. 1) marks the eastern continuation of the Hissartang Thrust. The presence of these few outcrops of the Samana Buk Formation at the southern foot of the Attok-Cherat Range strongly support the idea that the Hissartang Thrust is running at the foot of the Attok-Cherat Range rather than under the alluvium of Nizamapur Basin.

Rocks of the Kalachitta Range are exposed south of the Attok-Cherat Range. In Nizampur area they form a big synclinorium, gently plunging towards south east, with the rocks tightly folded on both the limbs (Plate 13). The presence of the Jurassic Limestone at the foot of the Attok-Cherat Range shows that the Kalachitta sequence extends under the alluvium of the Nizampur Basin upto this range (Plate 14).

East of Indus River several large and small isolated outcrops of fossiliferous limestone, covering parts of the
unfossiliferous Inzari, Hubartang and Darwazi formations, were previously identified as the Lockhart Limestone of Paleocene age (Rao and Latif, 1985). This limestone has a sheared unconformable lower contact with the Palaeozoic rocks (Yeats & Hussain pers. comm.).

During the present study it was found that this limestone contains some megafossils and it was suspected that it may be of Jurassic age. The fossils found in this limestone are identified by Dr. A.N. Fatah of G.S.P. as the corals of Jurassic age. This discovery has added more complexity to the structure of the area.

The field relationship of this rock unit with the underlying rocks is unique. In the entire Attock-Cheraot Range west of Indus, this limestone is found only at one peak, overlying the Inzari Limestone (Plate 15). However east of Indus, the same range has at least five mappable outcrops of Jurassic Limestone in the form of roofless patches lying on different Palaeozoic rock units, about one meter thick, pink colored, crushed quartz (Plate 16) marks the tectonic contact of Jurassic Limestone with the underlying rock units almost everywhere. Besides, a dolerite intrusion is present at the contact of Jurassic Limestone and Inzari Limestone at the top of the hill (Fig.8). This structure can be traced for about half a kilometer distance along the contact. In the central part the intrusion is about 6 m thick. At the margins, instead of exposed dolerite rock, the trace of the body can be seen as a reddish or rusty brown, colored weathered material. This intrusion was previously marked as a laterite band and was considered to mark an unconformity between Lockhart
Limestone and underlying Palaeozoic sequence (Yeats & Hussain, 1965).

The present study shows that in the eastern block of the Attock-Cherat Range the contact of the older rocks with the Jurassic limestone is of tectonic origin (Plate 16). Thus the main problem encountered during this work was the contrast between the Palaeozoic and Mesozoic rock relationship and a number of small faults oriented every which way, complicating the structure across the Indus River. In the Attock-Cherat Range, there are two main thrusts and the intervening block has uniform stratigraphy and structural behaviour almost up to the River. East of the Indus River, in a small area the structural style changes to a great extent as compared to the western side. This anomaly needed a thorough mapping of this part of the range and a serious effort to find out what was going on. The eastern block is therefore, mapped on a large scale (Fig. 8) to show more stratigraphic and structural details. Several cross-sections (Fig. 9, 10, 11) have been drawn for better understanding of the structure and finally a model has been evolved to explain this contrasting behaviour.
TEC TONIC INTERPRETATION

A. GENERAL INTRODUCTION

Yeats and Hussain (1986) on the basis of the presence of Lockhart, Patala and Murree formations across the Cherat and Hisаратang thrusts, and the absence of Mesozoic rocks north of the faults, suggest that post-Murree displacement on these faults is insignificant as compared to the large pre-Paleocene movement. But now the discovery of the fossiliferous limestone and the confirmation of its age, changed the story to a greater extent. Most of the limestone, especially in the east, mapped by the earlier workers as the Paleocene Lockhart Limestone, is now proved to be the limestone of Jurassic age. This Jurassic limestone has been mapped as lying unconformably on Paleozoic rocks (northern block) and is directly in contact with the Cherat Thrust in the eastern part of the area (Fig. 8). In the same area, the Jurassic limestone south of the Hisаратang Thrust has a different style, discussed later.

The discovery of Jurassic strata lying on top of Paleozoic rocks of the southern block indicates that pre-Paleocene movement on the two major thrusts of the area may not be as strong as was thought earlier.

The movement on Cherat and Hisaratang thrusts during Cretaceous time brought Dakhna Formation and lower Paleozoic rocks in juxtaposition; later erosion partly removed the rocks of Mesozoic time from these blocks. It seems odd that east of the
Indus River in the Attock-Cherat Range, Jurassic strata are extensively present on Inzari, Hissar Tang and Darwaza formations as rootless patches. Since the early workers mapped the Jurassic limestone as Palaeocene, they have not taken into consideration the range occurring eastwards. The Hissartang Thrust in this area is clearly running within the Darwaza Formation, the indication of which is very well pronounced (Plate 17). Besides, the fault pattern on the eastern side is also very different. Several small faults, apparently having no bearing with the regional fault geometry, are mapped in this area. The main block of Inzari Limestone is abruptly truncated in the strike direction in the extreme east (Fig.1). East of the Indus River and south of Hissartang Thrust, an intricate system of faulting is present. Here the Hissartang Formation is downfaulted in a small graben, surrounded by the Darwaza Formation (Fig.9).

B. EVIDENCE OF OVERTURNING IN PALAEOZOIC SEQUENCE OF THE ATTOCK-CHERAT RANGE.

The isolated low lying hillocks of Darwaza Formation at the foot of the Attock-Cherat Range west of Tarkhel village display an overturning of strata (Plate 19). The lower limestone unit of Darwaza Formation shows tight folding at small scale. These folds are south verging but in some layers north verging folds have also been observed. In one outcrop, the limestone beds are folded and overturned with a small fault marking the axial plane trace. This exposure confirms the large scale folding of the unit but the other limb is not clearly exposed to show...
overturning. Besides, this is the only outcrop out of few poorly
exposed parts of the formation where this feature can be seen.
The more convincing evidence of overturning, however, is
provided by the younger maroon shale unit of Darwazai Forma-
tion exposed in a large outcrop. Here the limestone and shale units of
this formation are dipping north but the shale (younger unit) is
underlying the older limestone unit (Plate 11).

The large scale folding is also found in the Inzar Formation (Plate 19). Tight folding is present in the argillites of
the Hissartang Formation (Plate 20). All these evidences favor a tightly folded (may be isoclinal folding) Palaeozoic
sequence with the axial plane dipping towards north.

The observation here is therefore different from Yeats &
Hussain (1980), who believe that "southern block consists of
north dipping homocline that is right side up, as
indicated by cross bedding in the quartzite of the Hissartang
Formation".

C. HISSERTANG THRUST AND THE NORTHERN MARGIN OF THE
KALACHITTA RANGE.

The Hissartang Thrust is traced from Mirkalan and Gaser Mela
villages in the west through Amiru village between a small
Jurassic outcrop of the Kalachitta Range and Palaeozoic rocks of
the Attock-Cherat Range (Plate 12). Further east Yeats & Hussain
(1986), have shown it running under the alluvium upto the
Campbellpur Basin. The Hissartang Thrust is the major structure
separating the Attock-Cherat Range from the Kalachitta Range. The
Jurassic strata at Amirud village belong to the Allahabat Range and constitute the northern boundary of the range (Plate 17). This contact of Darwazai Formation of the Attock-Cherat Range with the Jurassic strata of Saeeda Sul Formation (?) marks the location of Hissartang Thrust (Fig. 1). Further east there is a sizeable exposure of Jurassic limestone between Inzari and Tarkhel villages. This gently dipping limestone is continuously being excavated for construction purposes. At Tarkhel village there is a sharp contact between the gently dipping Jurassic limestone with the steeply dipping quartzite of the Hissartang Formation. This is the place where the Hissartang Thrust reappears.

East of Darwazai village a major NW trending fault is marked with in the Darwazai Formation with a distinct fault breccia zone (Plate 17) which extends eastwards across the river. This fault brings Darwazai Formation in direct contact with the younger Inzari Formation in the eastern part of the range (Fig. 6). Its eastern continuation across Indus River swings NE and runs close to Cherat Fault. The author believes that this structure marks the eastern continuation of the Hissartang Fault. East of Indus, the area south of this fault which is in contrast with the rest of the Attock-Cherat Range has developed the crop-out sections because of a complex system of back-thrusting and faulting.

Another feature related to Hissartang Thrust is the presence of four splay faults that branch off from the Hissartang Fault near Inzari and Darwazai villages in Khwari Khwar section and in the area east of Indus River (Fig. 1, Plate 21 & 22). These splay faults extend upto Cherat Thrust and may be the
connecting splays of the two major thrusts in this area.

A doubly plunging synclinorium (Plate 23) in the Kalachitta Range north of the Indus River, near Khai village, exposes Sasanuk Formation of Jurassic age at the two limbs. The Jurassic strata constituting the northern limb of the synclinorium gradually vanish under the alluvium with occasional outcrops exposed for some distance northward till it is all covered by the thick valley fill deposits of the Indus, once flowing through this area. The same Jurassic limestone of the Kalachitta Range again starts appearing close to the Attok-Cherat Range near Tarkhel village.

These observations indicate that Hisbertang Thrust is running in most part at the southern foot of the Attok-Cherat Range; a position which is further north of its previous location as given by Yeats & Hussain (1984). The presence of Jurassic strata at Amiruh and Tarkhel villages indicates that the rocks of the Kalachitta Range extend all the way under the thick alluvial cover of the Nizampur Basin up to the Attok-Cherat Range (Fig. 12).

D. THE PROPOSED STRUCTURAL MODEL FOR EASTERN BLOCK.

A model is presented by drawing a series of cartoons (Fig. 15 a,b,c,d) to explain the structure of the Attok-Cherat Range. The idea is, that the Cherat Fault developed prior to the deposition of Paleocene and younger rocks. The thrust system advanced towards south bringing Dahan Formation on top of
FIG. 12. A CROSS SECTION ALONG F'-F' LINE OF FIG. 1 COVERING PARTS OF THE ATTOCK-CHERAT AND KALACHIITA RANGES, WEST OF INDUS RIVER.
Palaeozoic and Mesozoic rocks. At the same time a lower thrust, i.e. the Hissartang Thrust, produced which pushed Palaeozoic and Mesozoic rocks of the Attock-Cherat Range on Mesozoic sequence of the Kalachitta Range. A small branch of the Hissartang Thrust (Hissartang splay) was cut off from the main fault which pushed a wedge of Palaeozoic Sequence below the Mesozoic rocks, producing a low angle Hissartang back-thrust along which Mesozoic strata was thrust over the Palaeozoic rocks. The triangle of the Palaeozoic rocks (Fig. 13 c) later on developed some listric and high angle faults further complicating the situation.

It is believed that the eastern block of the Attock-Cherat Range is a part of this tectonic slice or triangle but it has structurally different setting as compared to the Palaeozoic sequence, west of Indus. The fault which brings Injizi and Darwazai formations in contact with each other and other small faults producing the graben are the listric and/or high angle faults restricted to this zone (Fig. 6). Hissartang Thrust shifts north in this part of the area and lies close to Cherat Thrust. The Palaeozoic sequence north of the Hissartang Thrust comprises of Darwazai and Hissartang formations with a Jurassic strata lying unconformably on them. The main southern block of the Attock-Cherat Range therefore gets fairly squeezed, east of Indus.
FIG: 13 a,b,c,d, THE PROPOSED STRUCTURAL MODEL FOR EASTERN BLOCK OF THE ATTOCK-CHERAT RANGE.
CONCLUSION

The main structural features of the Attok-Cherat Range are the three E-W striking thrust faults. These are produced as a consequence of the shortening because of the push from the north. These faults (from north to south) are:

1. The Khairabad Thrust
2. The Cherat Thrust and
3. The Hissartang Thrust.

The Khairabad Thrust is the boundary between the Precambrian slates, phyllites, quartzites, limestones and unfossiliferous flysch deposits (Dakhner Formation) of Precambrian age. Dakhner Formation being least competent is highly deformed Dakhner Formation, in turn, is thrust over the Paleozoic and Mesozoic sequence along Cherat Thrust. Paleozoic and Mesozoic strata, being comparatively competent, is less deformed. The Hissartang Thrust marks the boundary between the rocks of Attok-Cherat and Kalashitta Range. The rocks of the Kalashitta Range are deformed due to the movement along this thrust. They form a big doubly plunging synclinorium with smaller south verging folds on its limbs.

During the present study the following conclusions are made:

1. Previously the rocks south of the Khairabad Thrust were considered to be a hemoclise (Yeats & Hussain, 1986) but the author suggests a south verging tight fold system. Its southern limb is truncated against the Hissartang Thrust.
3. The occurrence of Jurassic limestone at the southern foot of the Attock-Cherat Range helped to relocate the Hissartang Thrust. This thrust was marked in the western part of the Attock-Cherat Range by Yeats & Hussain (1986), but eastward they extended it under the alluvium. This thrust has complicated the structure of the Attock-Cherat Range in the eastern most part because it cuts through the Paleozoic sequence.

3. A structural model is proposed to explain the contrast in the structure and stratigraphy east of Indus River. The Hissartang Thrust cuts the Paleozoic sequence, turns NE and runs close to the Cherat Thrust. During southward movement, a small branch of the Hissartang splay is cutoff from the main fault pushing the wedge of the Paleozoic sequence under the Mesozoic sequence of the Kalachitta Range. This phenomenon produced a low angle back thrust along which the Mesozoic strata was back thrusted over the Paleozoic rocks. The rootless patches of Jurassic limestone lying on these rocks have a tectonic contact, which is clearly indicated by a zone of crushed quartz at the contact. Within the wedge come listric and high angle faults are developed in this area.
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Plate 1. Carbonaceous shales with in the Dakhner argillites NE of Inzari village.
Plate 2. The well foliated Dakhner argillites, having fractures developed parallel to the axial plane of the folds.
Plate 3 & 3a. Current ripple marks in Lasker Formation.
Plate 4. The unconformable Lockhart Limestone (in patches) lying on Dakhneer Formation.
Plate 5. Thin greenish and white alternating bands of Darwasai Limestone.
Plate 6. Thin purple and yellowish brown bands of calcareous shales of Darvazai Formation.
Plate 7. Thin bedded Inmari Limestone having a small box fold.
Plate 0. Small scale fault (FF) in Inzeri Limestone.
Plate 9. The resistant limestone bands alternating with the soft shales of Karkas Formation.
Plate 10. The folded argillites of Dakhna Formation.
Plate 10a, b. "Z" type drag folds in Dakhner argillites.
Plate 11. The younger maroon shale underlies the older limestone of Darwaza Formation showing an overturned position near Tarkhel village.
Plate 12. The Hissârtang thrust (FF) between Jurassic rocks (left) and Darwazal Formation (right) near Amiruh village.
Plate 13. The core of the synclinorium with in the rocks of the Kalschite Range, in Nizampur area.
Plate 14. The Jurassic Limestone of the Kalachitta Range exposed at the southern foot of the Attock-Cherat Range. In the background are the sediments of the Muzaffarpur Basin.
Plate 15. The only exposure of Jurassic Limestone (in western area) having a faulted contact with the underlying Izgari Limestone, west of Tarkhel village.
Plate 16. The contact between the Missartang Formation (lower) and the Jurassic Limestone (upper), east of Indus River. The presence of crushed quartz between the two formations indicates the tectonic contact.
Plate 17. The area within the lines shows fault breccia (whitish) and recrystallized limestone (brownish) along the Hissartang Fault.
Plate 16. The core of the overturned anticline in the limestone of Tarwazzi Formation near Tarkhel village.
Plate 19. "Z" type folds in Inzari Limestone.
Plate 20. 'S' type drag fold in Hisar Tang Formation.
Plate 5: North south striking fault in the upper quartzite of the Hissartang Formation (Bori Khwar section). This fault is considered as the branch fault of the Hissartang Thrust.
Plate 22. The same fault as in the plate 21, in the upper quartzite of the Hissartang Formation in Khuari Khwar section.
Plate 23. Doubly plunging synclinorium in the rocks of Kalachitta Range.
To,
The Director,
MCS in Geology,
University of Peshawar.

SUBJECT: EVALUATION OF AN M.PHIL. THESIS SUBMITTED BY M. KHALED PARVEZ.

It gives me pleasure to express my views about research produced by Mr. Khaled Parvez in the form of his M.Phil thesis on "Geology of a part of Attock-Charot and Kalachitta Ranges in the vicinity of Risapur, NWFP, Pakistan".

I have critically reviewed his work and had a thorough discussion with him in the presence of his supervisor, Mr. Arif Ali Khan Ghauri. Mr. Khaled on the basis of his thorough field investigations and precise mapping of Central and eastern stretch of Attock Churat and part of Kalachitta Ranges has very convincingly located the trace of Kissan Tang fault which separate the two ranges. The discovery of Jurassic Strata, specially in the eastern block of Attock-Churat Range which was earlier mapped as Paleocene Lakhzwar Limestone is a milestone in the better understanding of the Geology and Structure of this part of Pakistan. He has rejected several old views advocated by earlier workers and set some new guidelines for future worker. The speciality of his work is the suggested new structural model for explaining complicated lithological and structural relationship seen east of India.

I considered this work to be of great scientific value. Mr. Khaled and his supervisor deserve the credit for producing a valuable original research.

I strongly recommend this thesis for the award of an M.Phil. degree.

Yours sincerely,

(All Asad Ayyad)
Geologic Consultant
and director.

TEKNIK INTERNATIONAL
CONSULTING AND TRANSFER OF TECHNOLOGY
COMMODITIES AND EQUIPMENT SUPPLY
The Director,
Centre of Excellence in Geology
Peshawar University
Peshawar.

SUB:— EVALUATION OF M.PHIL. THESIS

Dear Sir,


I have examined the thesis entitled "Geology of a part of Attock - Ghizer and Kalashita ranges in the vicinity of Nizampur NFPP, Pakistan", submitted by Mr. Khalid Parvez.

Mr. M. Khalid Parvez has done a detailed geological work on the area studied including mapping of the area. In my opinion the thesis is quite enough for the conferring of M.Phil degree. The copy of thesis is enclosed herewith.

Yours sincerely,

[Signature]

(Dr. Muhammad Niamatullah)
Chairman.
NATIONAL CENTRE OF EXCELLENCE IN GEOLOGY
UNIVERSITY OF PESHAWAR
(PAKISTAN)

No. ......................  Dated ...................... 198

RESULT OF EXAM. -- SEP. 1982

Name of the Candidate: Mr. M. Shabir Parvez
Father's Name: M. Ali Khan
Qualification: M.Phil. Dissertation
Topic of Research: Geology of a part of Attock-Cheraat and Malakot ranges in the vicinity of Miramur, NWFP, Pakistan.

"We have examined the M.Phil. thesis of Mr. M. Shabir Parvez and have discussed the research with him. We found him competent in his work which he has presented in this dissertation. We strongly recommend this thesis for the award of the degree of Master of Philosophy."

1. External Examiner
   A. Kosev
   Geologic Consultant
   and Director, Teknica International France

2. Internal Examiner and Supervisor of the thesis
   Professor Arif Ali Khan Obaid, M.C.G. in Geology
   University of Peshawar

3. Director

[Signatures]