Journal of Nepal Geological Society, 1995, Vol. 10, pp. 1-9

The Kala Chitta foreland fold and thrust belt, Northern Pakistan

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ABSTRACT

The present structural framework of the Kala Chitta Range evolved through movement between two detachment surfaces. The Precambrian Attock Slates acted as a basal detachment surface above which large scale horizontal compression took place to produce the main structural framework of the Kala Chitta Range. The Middle Eocene argillaceous and gypsiferous Kuldana Formation behaved as the upper detachment surface giving rise to blind thrusts which were later exposed due to the intense erosion of the overlying folded Miocene strata.

INTRODUCTION

The Kala Chitta Range forms a part of the northwestern margin of the Indian Plate (Fig. 1). It is situated within the zones of active folding and thrusting. The pre-Tertiary dissimilar stratigraphic relationship, and afterwards, the similarity in the Tertiary stratigraphic framework between the Kala Chitta Range and its northerly neighbour, the Attock-Cherat Range, has already been pointed out by Yeats and Hussain (1987).

Despite the severe tectonic activity, strata older than the Triassic are not exposed in the Kala Chitta Range, and it appears that these strata may not have been deposited at all. However, the Precambrian Attock Slates are believed to underly the Mesozoic rocks because of their intervening position between the Kala Chitta Range and the Attock-Cherat Range.

The salient features of the sedimentary geology and the geological history of the Kala Chitta Range (Akhtar and Khan, 1983, Butt, 1987) can be summarised as follows:

The structural configuration of the Kala Chitta Range evolved during the Triassic when the shallow water marine sedimentation took place in a narrow belt to deposit the Miawali Formation, the Chak Jabbi Limestone and the Kingriali Formation. It is followed by a regressive phase during the early Jurassic (Datta Formation).

The Upper Jurassic Samana Suk Limestone deposition marks the major transgressive episode with enlarged shallow water marine environments.

Later, anoxic environments were largely introduced to produce typical black shale facies of the Belemnite bearing Upper Jurassic Chichali Formation. A thin lateritic crust between the Samana Suk Limestone and the overlying Chichali Formation marks a minor depositional break. However, return of open marine shallow water environments were envisaged during the deposition of the Lower Cretaceous glauconitic Lumshiwal Sandstone.

In the Upper Cretaceous time (Coniacian to Campanian) shrinking of the marine environment was encountered. The conditions were confined to the northern Kala Chitta Range for the deposition of the Kawagarh Formation. The deepening tendency of the Kala Chitta Range was suggested by virtue of the presence of planktonic foraminifera (Globotruncana biofacies) in the Kawagarh Formation. It is developed as an argillaceous limestone with a distinctive platy habit. A stratigraphical break (Cenomanian-Turonian) is evidenced between the Lumshiwal Sandstone and the overlying Kawagarh Formation indicated by the presence of hard ground and faunal contents.

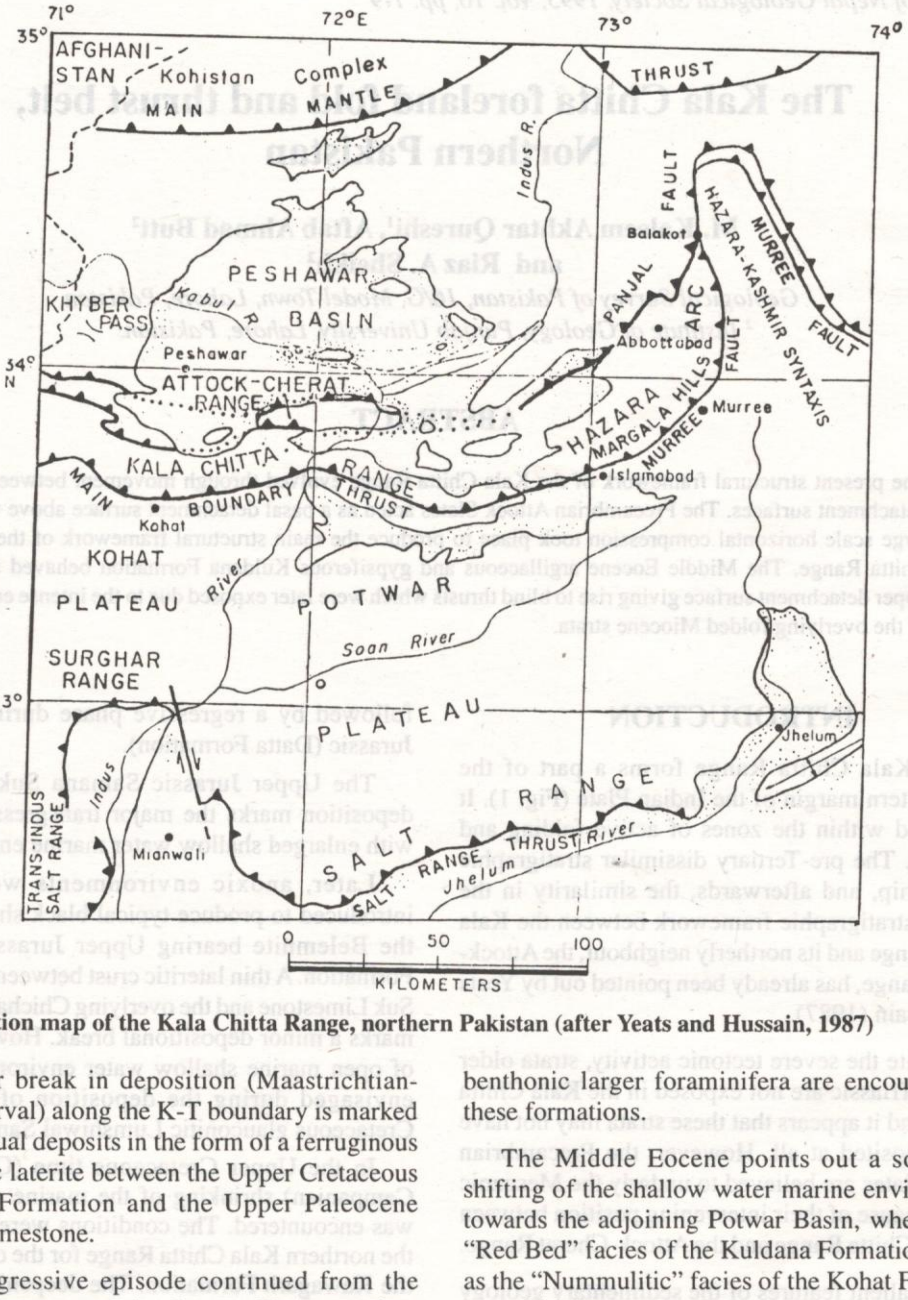


Fig. 1: Location map of the Kala Chitta Range, northern Pakistan (after Yeats and Hussain, 1987)

A major break in deposition (Maastrichtian-Danian interval) along the K-T boundary is marked by the residual deposits in the form of a ferruginous and pisolitic laterite between the Upper Cretaceous Kawagarh Formation and the Upper Paleocene Lockhart Limestone.

A transgressive episode continued from the Upper Paleocene to the Lower Eocene when widespread shallow water marine environments prevailed to deposit the Upper Paleocene nodular Lockhart Limestone and the argillaceous Patala Formation as well as the Lower Eocene nodular Margala Hill Limestone and the flaggy limestone and dolomite (Chorgali Formation). Age-diagnostic benthonic larger foraminifera are encountered in these formations.

The Middle Eocene points out a southward shifting of the shallow water marine environments towards the adjoining Potwar Basin, when typical "Red Bed" facies of the Kuldana Formation as well as the "Nummulitic" facies of the Kohat Formation were laid down.

A major depositional gap occurs from the Upper Eocene to the Oligocene marked by a thin basal conglomeratic deposit (The Fatehjang Member). This coincides with the maximum structural evolution of the Kala Chitta Range. The onset of the non-marine Miocene sedimentation (Murree

Formation) is thus observed along the southern end of the Kala Chitta Range.

The Kala Chitta Range has been mainly a shallow subsiding trough during its geological history as is evidenced by the sedimentary facies and the associated fauna but deepening tendency was found during the Upper Cretaceous.

According to Chapple (1978), the foreland fold and thrust belts and accretionary wedges generally have the following features in common:-

A basal zone of decollement, which is composed of a weak rock and dips towards the interior of the mountain belt or volcanic arc.

Large scale horizontal contraction of strata above the basal decollement.

Little or no deformation below the zone of decollement.

Overthrust strata with a characteristic wedge shape, tapering towards outer edge of the orogen.

The present paper, however, draws attention towards the recognition of the Double Decollement Surfaces in the Kala Chitta foreland fold and thrust belt. The tectonic map (Fig. 2) and the cross sections (Figs. 3, 4) of the Kala Chitta Range gives the structural framework.

STRUCTURAL SETTINGS

In the Kala Chitta Range, Triassic to Lower Eocene rocks are repeated constantly in compressed folds and thin sheets. Interpretation of a regional decollement (Cotter, 1933) rooted in the Attock Slates and responsible for major overthrusting, has proved to be of fundamental significance for later researchers. The sedimentary veneer has glided and deformed over this surface and the Attock Thrust and the Main Boundary Thrust represent splays off this detachment surface. Late Cenozoic movement along these thrusts has uplifted the Attock-Cherat and the Kala Chitta Margala Hill Ranges.

Apart from movement over this basal decollement surface, the Kala Chitta fold and thrust belt has evolved by blind thrusts merging with a continuous upper detachment surface. The Middle Eocene argillaceous and gypsiferous Kuldana Formation is believed to have played the role of an upper detachment surface. This view is supported by the fact that the Kuldana Formation and the overlying molassic deposits which are well exposed all along the southern borders of the fold-thrust belt, are not repeated in any of its internal folds. The presence of the Pre-Kuldana early Tertiary limestone - marls bearing rocks (i.e., Margala Hill Limestone/ Patala Formation/Lockhart Limestone) in the footwalls of almost all the exposed thrusts, regardless of which formation comprises the hanging wall, also provides a strong evidence of the fact that the Kuldana Formation has served as the upper detachment surface. This consistancy shows that successive thrust emplaced at the outer edge of the foot hills flattened along a common upper detachment surface formed by the Kuldana Formation.

The recognition of the basal and upper detachment surfaces gives a distinctive character to the deformational style of the Kala Chitta foreland Fold and Thrust belt. The sequence of events describing briefly the changes in structural style with different erosion levels, and the development of blind thrusts beneath a continuous upper detachment surface at all stages of deformation are modelled in Figure 5, while Figures 6 and 7 further elaborate this concept. It is also very obvious from this model that the internal deformation of the Kala Chitta Range predates its ramping towards south over the Main Boundary Thrust (MBT). However, basement uplift to some extent, might have also been responsible for the initiation of thrusting in the Kala Chitta and the adjoining areas.

During its tectonic history, the Kala Chitta Thrust belt has suffered a number of deformational phases. However, in a very generalized sense, the most effective and prominent are three distinct and partly overlapping phases. The first and the oldest formed the east-west trending fold axes and fault planes. During second NE-SW trending phase, cross folds and duplex structures were formed, while the third phase resulted into the thrusting and ramping of the whole Kala Chitta belt over the Main Boundary Thrust to the south.

The overall configuration of the Kala Chitta Range indicates that during the final phase of thrusting over the Main Boundary Thrust (MBT),

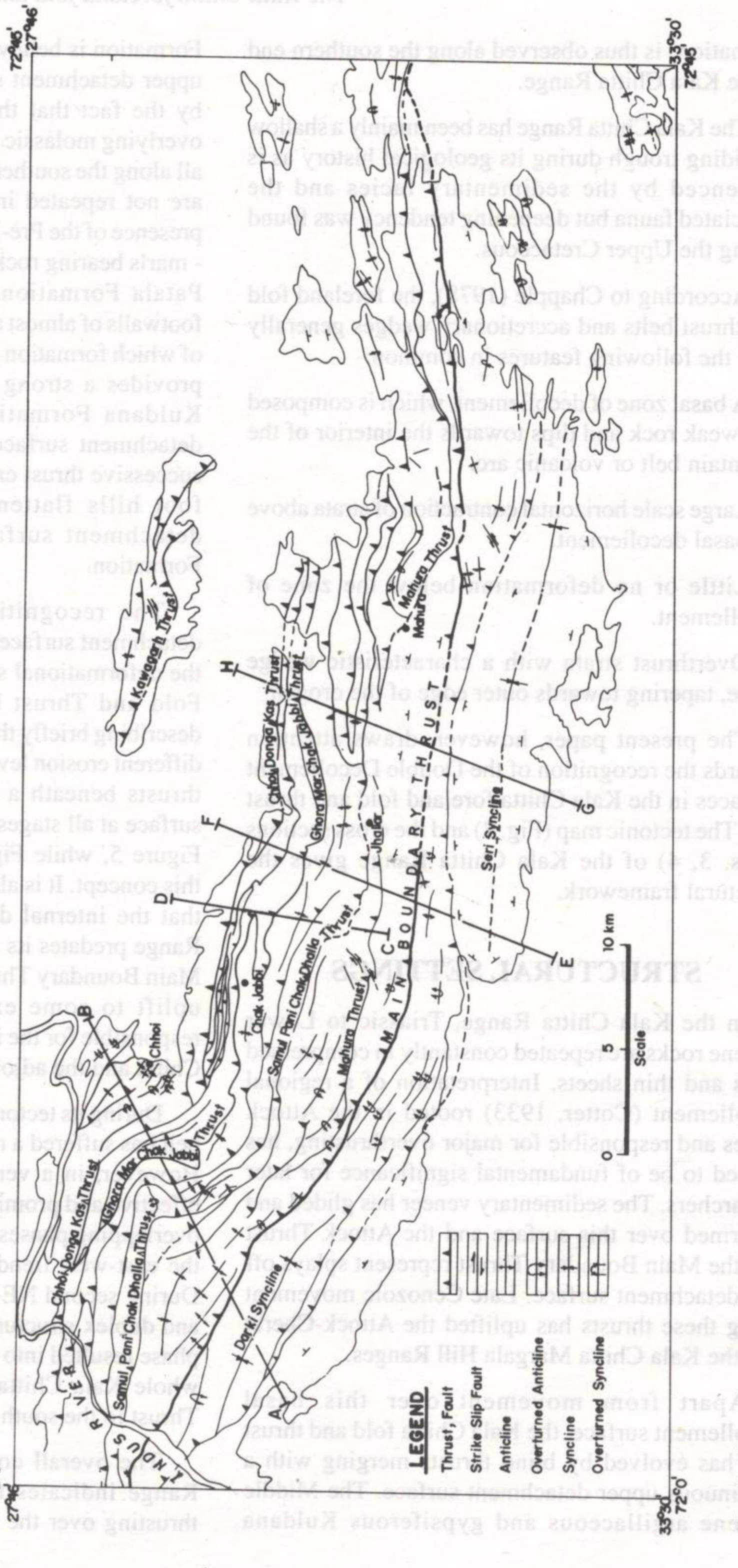


Fig.2: Tectonic map of the Kala Chitta Range

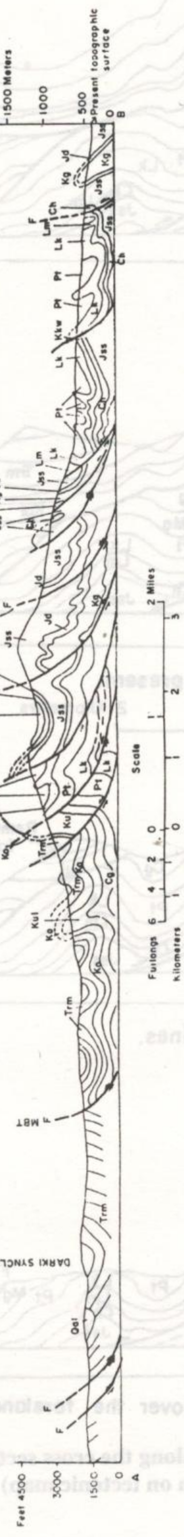


Fig. 3: Geological crosssection along the line A-B, across Ranikot Peak and Chhoi Village (location shown in Fig. 2)

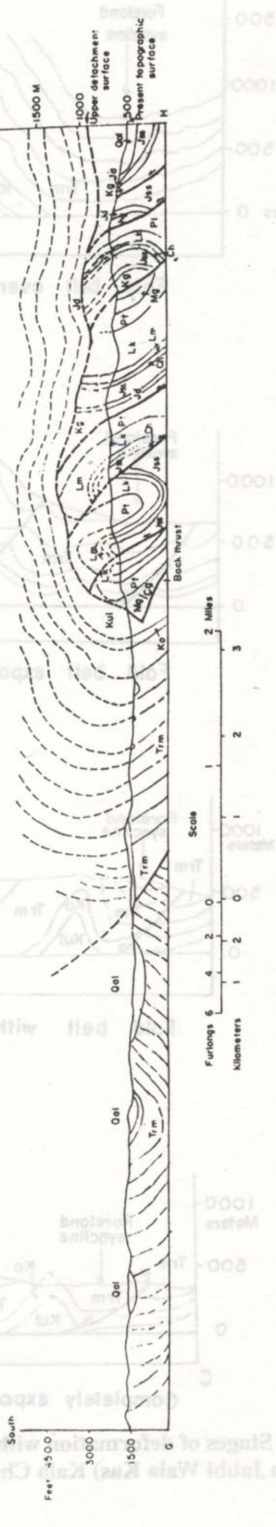


Fig. 4: Geological crosssection across Jodhwali Dhok and Dhok Mochian (along the line C-D). The speculative position of the overlying fold belt and upper detachment surface is also shown.

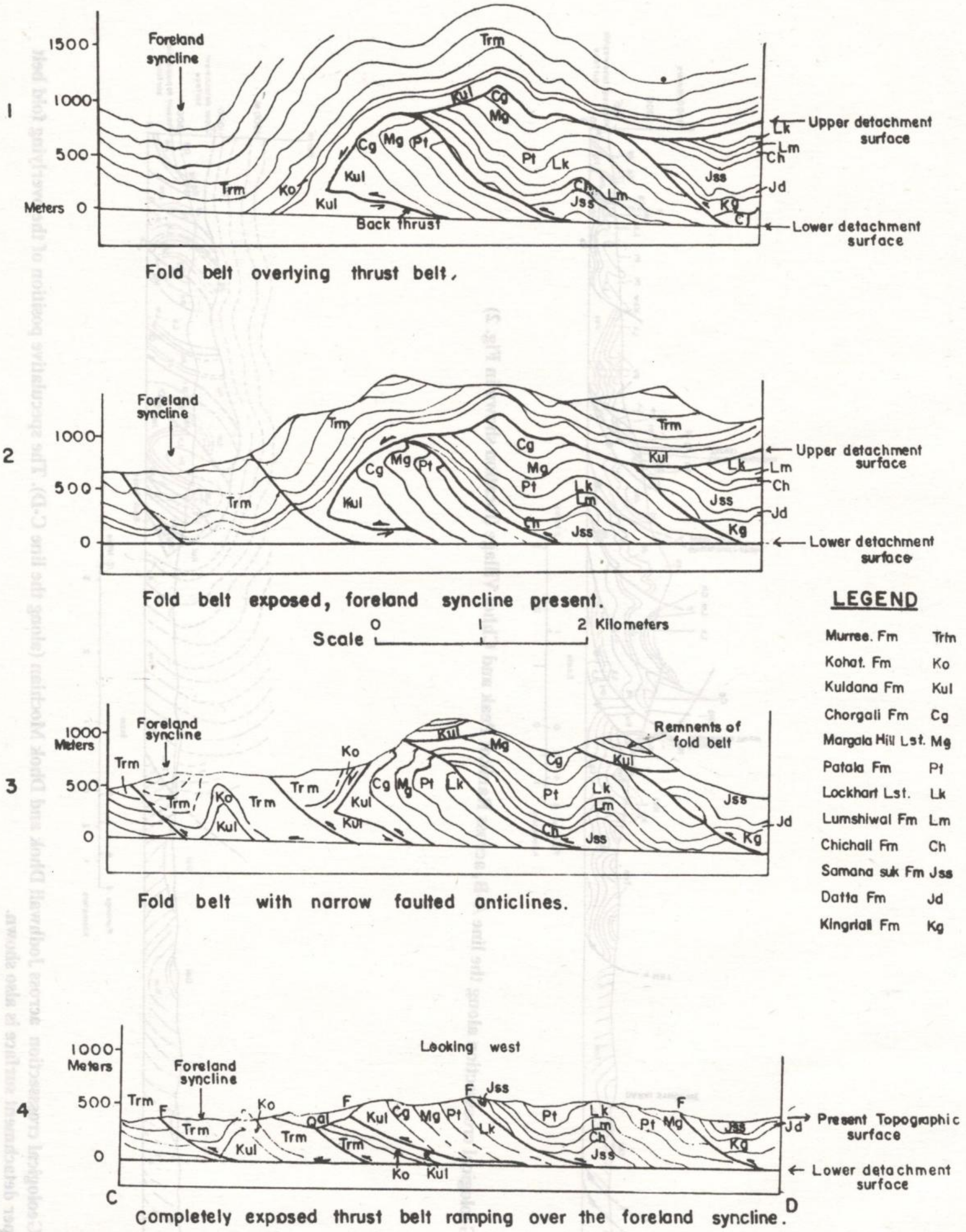


Fig. 5: Stages of deformation with different levels of erosion along the cross section line C-D (Burjian Wala Laman Jabbi Wala Kas) Kala Chitta fold-thrust belt (location on tectonic map)

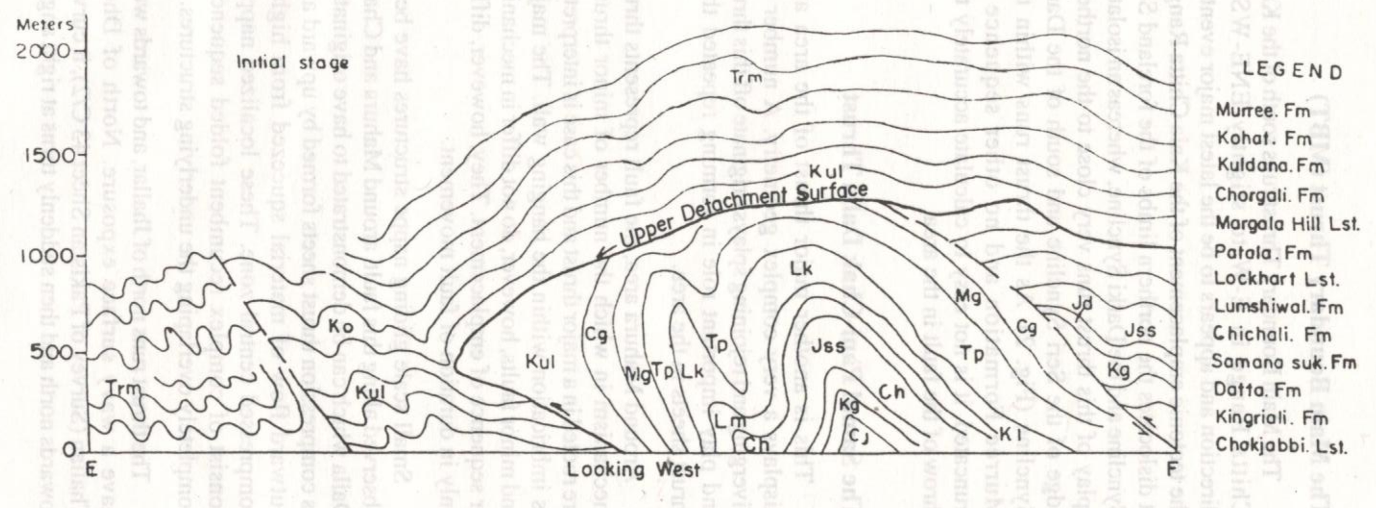
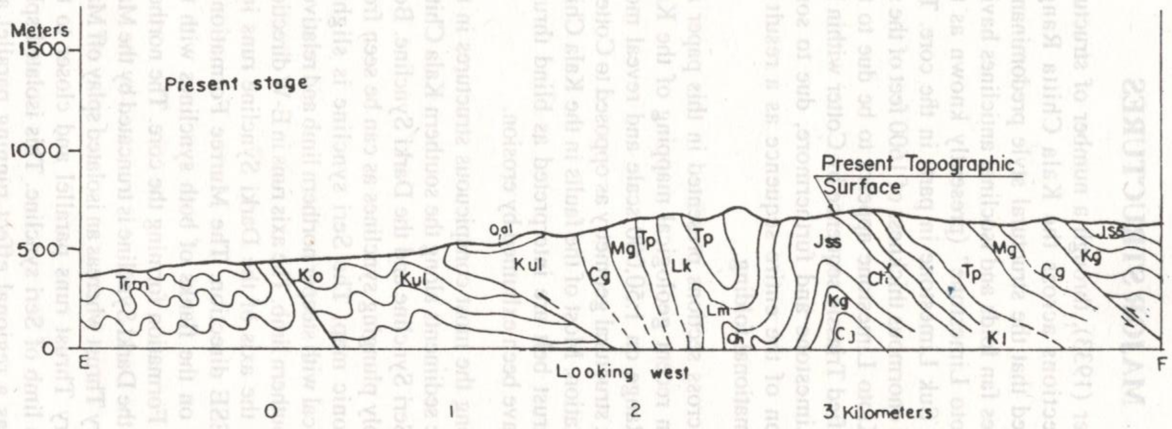


Fig. 6: A schematic geological crosssection west of Jhallar Railway Station (The fold belt overlying the thrust belt)



differential block movement took place, the western block lagged behind in southward movement and much thrusting developed in its extreme northern part (Chhoi-Chak Jabbi area). On the other hand, the eastern block moved ahead towards south, developing extensive thrusting towards its south (Fatehjang Mahura area).

MAJOR STRUCTURES

Cotter (1933), through a number of structural cross sections across the Kala Chitta Range, concluded that the structural style predominantly comprises fan folds and isoclinal anticlines having the "Kioto Limestone" (presently known as the Samana Suk Limestone in part) in the core. The reported enormous thickness of 1600 feet of the so-called Kioto Limestone appears to be due to the unidentified Triassic sequence by Cotter within his Kioto Limestone and furthermore, due to some repetition of the entire sequence as a result of intraformational folding.

The cross sections presented in this paper are based on recent geological mapping of the Kala Chitta Range on 1:50,000 scale and reveal more complex structural geometry as opposed to Cotter's interpretation. Most of the faults in the Kala Chitta Fold-Thrust belt are interpreted as blind thrusts which have been exhumed by erosion.

Among the most conspicuous structures in the molassic sediments along the southern Kala Chitta, are the Seri Syncline and the Darki Syncline. Both are doubly plunging synclines as can be seen from the tectonic map. The Seri syncline is slightly asymetrical with steeper northern limb and relatively gentle southern limb. The axis runs in E-W direction, whereas the axis of the Darki Syncline runs in a WNW-ESE direction. The Murree Formation is exposed on the flanks of both synclines with the Kamlial Formation forming the core. The northern Limb of the Darki Syncline is truncated by the Main Boundary Thrust whereas an isolated splay off Main Boundary Thrust runs parallel and closer to the northern limb of Seri syncline. This isolated splay thrust has a regional effect running parallel and thrusted south of Main Boundary Thrust, whereas towards west it disturbs the southern limb of the Darki syncline.

The major faults include the Main Boundary Thrust, the Samul Pani-Chak Dalla Thrust, the Ghora Mar-Chak Jabi Thrust, the Chhoi-Dunga Kas thrust and their splays and off shoots. Their general descriptions are as follows:-

The Main Boundary Thrust (MBT)

The Main Boundary Thrust runs south of the Kala Chitta Range in E-W to slightly ENE-WSW direction and appears to be the latest major event in the tectonic emplacement of the Kala Chitta Range. It dislocates the northern limbs of the foreland Seri Syncline and the Darki Syncline, whereas an isolated splay of this thrust runs very close to the northern edge of the Seri Syncline and south of the Darki Syncline (Fig. 2). As the thrust runs within the Murree Formation and no other sequence is truncated, it is not easy to calculate accurately the throw of the fault in the area.

The Samul Pani-Chak Dalla Thrust

This is another major thrust of the area and displays a very complex geometry. A number of diverging and rejoining splays originate off this thrust and play important role in forming repeated thin thrust sheets in the area.

Around Mahurá area, the fault represents thrust mechanism in which the number of minor thrusts are rooted in a major thrust and this case is interpreted as imbrication within the hanging wall. The major and minor faults, however, do not differ in mechanics or sequence of emplacement. They, however, differ only in duration of fault movement.

Small scale gliding nappe structures have been observed along this fault, around Mahura and Chak-Dalla which can be demonstrated to have originated as compression thrust sheets formed by upward and outward flow of material squeezed from highly compressed central zone. These localized nappes consist of complex recumbent folded sequences completely overlaping the underlying structures.

The thrust runs north of Jhallar, and towards west have a wavy surface exposure. North of Dhok Thalian (Survey of Pakistan Sheet 43 C/2), it curves towards north and then suddenly turns at right angle, running in an east-west direction again. A rejoining splay is also present probably compensating the sudden tectonic bend. Towards west, displacement along this fault appears to subside and it runs within Paleogene strata and crosses Indus river into Nizampur hills.

Ghora Mar-Chak Jabbi Thrust

Near Chak Jabbi Rest House, Triassic Formations are thrusted with the Palaeocene and the Lower Eocene rocks. The Ghora Mar-Chak Jabi Thrust to the south of Akhori and Chak Jabbi as well as west of the Ranikot Peak makes hair-pin bends as a result of cross folding. This is also evident from these tight fault loops, that secondary tectonic phase has generated movement in the pre-existing faults instead of producing new fault planes. This displacement along this fault varies, and south of Chak Jabbi village, the throw is 300 to 400 meters as Samana Suk Formation is thrust over the Margala Hill Limestone (considering the thickness of cut off and displaced rock formations). The dips near the surface are high ranging from 45 to over 55 NE.

Chhoi-Dunga Kas Thrust

Its most conspicuous feature is the development of the Chak Jabbi Imbricate Zone, formed by minor thrusts rooted in the major thrust. It is however, different from the Samul Pani-Chak Dalla Fault in having imbrication in the footwall of the major thrust. The throw of fault towards the east is greater (as Chak Jabbi Limestone is thrusted over the Samana Suk Limestone) than towards the west (the Samana Suk Limestone is thrusted over the Lumshiwal Formation).

CONCLUSIONS

The Kala Chitta Range exemplifies the tectonic style of a foreland fold and thrust belt, where the Precambrian Attock Slates served as a basal detachment surface, while the Middle Eocene argillaceous and evaporitic Kuldana Formation formed the upper detachment surface.

Interpretation of Cotter's regional decollement rooted in the Attock Slates and responsible for major structural evolution of the Kala Chitta Range thus proves to be of fundamental significance.

The folding phenomenon is predominently secondary to faulting and folds may be classified as fault-bent folds or the fault propagation folds.

Majority of faults developed as blind thrusts below the upper detachment surface and are exposed by the erosion of the overlying fold belt.

Slight differential block movement has resulted in the western Kala Chitta in lagging behind in its southwardly motion, thus changing the general trend from E-W to ESE-WNW direction.

A number of deformational phases resulted to intensive cross folding.

The recognition of the Miocene Murree Formation in the northerly Attock-Cherat Range and its exposures in the southern border of the Kala Chitta Range as well as the structural disposition of the Murree Formation in relation to the Pre-Miocene strata, provides additional information to interpret the proposed structural modelling of the Kala Chitta Range.

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